State of California
The Resources Agency
Department of Water Resources

INTERIM REPORT CHARACTERIZATION OF FISH HABITAT IN ONE-MILE POND SP-F3.1, TASK 5B

Oroville Facilities Relicensing FERC Project No. 2100

JANUARY 2004

ARNOLD SCHWARZENEGGER
Governor
State of California

MIKE CHRISMAN
Secretary for Resources
The Resources Agency

LINDA S. ADAMS
Interim Director
Department of Water Resources

State of California
The Resources Agency
Department of Water Resources

INTERIM REPORT CHARACTERIZATION OF FISH HABITAT IN ONE-MILE POND SP-F3.1, TASK 5B

Oroville Facilities Relicensing FERC Project No. 2100

This report was prepared under the direction of

Terry J. Mills .... Environmental Program Manager I, DWR

by

Paul Bratovich ....Principal/Fisheries Technical Lead, SWRI
David Olson................................ Senior Environmental Scientist/Project Manager, SWRI
Jim Hornback ....Associate Environmental Planner/Author, SWRI
Adrian Pitts... Environmental Scientist/Author, SWRI

Assisted by

Amanda O' Connell .... Environmental Planner, Technical Research, SWRI

REPORT SUMMARY

SWRI staff analyzed the availability of warmwater fish habitat in One-Mile Pond. One-Mile Pond was chosen to represent fish habitat in the Oroville Wildlife Area (OWA) because it is a large pond with a variety of habitat types and is similar to other fish-bearing ponds within the OWA. Habitat suitability for native and introduced fish species known to exist in the lower Feather River below the Thermalito Afterbay Outlet and identified in Study Plan (SP)-F3.2, *Evaluation of Project Effects on Non-salmonid Fish in the Feather River Downstream of the Thermalito Diversion Dam*, was analyzed in One-Mile Pond. The habitat suitability analysis conducted in this report was based on a literature review of the water temperatures, dissolved oxygen concentrations, substrates, cover types, and depths reported as suitable, preferred, or optimal for each of the species with the potential to exist in One-Mile Pond. Habitat suitability was determined based on available literature for each lifestage of each species with the potential to occur in the OWA. In addition, habitat suitability was determined for species identified during DWR electrofishing efforts in One-Mile Pond that were not listed in the SP-F3.2 as existing in the lower Feather River below the Thermalito Afterbay Outlet. The reported habitat suitability criteria for each fish species were compared to actual habitat conditions recorded during DWR sampling efforts in One-Mile Pond.

Based on the reported water quality tolerance ranges and reported habitat preferences for the fish species potentially occurring in One-Mile Pond, it is likely that suitable habitat exists within portions of the pond for most non-native warmwater species identified as having the potential to occur within the pond.

Additionally, suitable habitat likely exists within One-Mile Pond for most native species identified as having the potential to exist in the pond based on the reported water quality tolerance ranges and on reported habitat preferences.

TABLE OF CONTENTS

LIST OF FIGURES

1.0 INTRODUCTION

1.1 BACKGROUND INFORMATION

Ongoing operation of the Oroville Facilities influence water temperatures and surface elevation fluctuations in One-Mile Pond and the Oroville Wildlife Area by influencing river stage. Water temperature and surface level fluctuation are important factors in influencing the availability of habitat for fishes in One-Mile Pond. As a component of study plan (SP)F3.1, *Evaluation of Project Effects on Fish and their habitat within Lake Oroville, its upstream tributaries, the Thermalito Complex, and the Oroville Wildlife Area*, Task 5 of SP-F3.1 describes fish species composition and characterizes habitat in the Oroville Wildlife Area ponds. Task 5B, herein, characterizes fish habitat in One-Mile Pond.

1.1.1 Statutory/Regulatory Requirement

Section 4.51(f)(3) of 18 CFR requires reporting certain types of information in the Federal Energy Regulatory Commission (FERC) application for license of major hydropower projects, including a discussion of the fish, wildlife, and botanical resources in the vicinity of the project (FERC 2001). The discussion is required to identify the potential impacts of the project on these resources, including a description of any anticipated continuing impact from on-going and future operations.

This task is additionally related to the FERC Relicensing of the Oroville Facilities because FERC has a long history of fish stocking in Lake Oroville and the Thermalito Forebay. In 1977, FERC approved the California Department of Water Resources' (DWR) Oroville Facilities Recreation plan entitled Bulletin No. 117-6 (Oroville Reservoir, Thermalito Forebay, and Thermalito Afterbay Water Resources Recreation Report), which provided plans for public utilization of project lands and waters for recreational purposes through the year 2017 (FERC 1994).

As a subtask of SP-F 3.1, Task 5B fulfills a portion of the FERC application requirements and provides documentation to support future implementation of Bulletin No. 117-6 by providing an analysis and characterization of fish habitat in One-Mile Pond. In addition to fulfilling these requirements, information collected during this task may be used in developing of evaluating potential Resource Actions.

1.1.2 Study Area

The study area in which the results of Task 5B of SP-F3.1 apply is One-Mile Pond, which was chosen to represent all fish-bearing ponds in the Oroville Wildlife Area. One-Mile Pond is a large pond that contains a variety of habitat types, including those found in other fish-bearing ponds of the Oroville Wildlife Area, such as a shoreline and substrate predominantly consisting of cobble, seasonally flooded terrestrial vegetation such as willow (*Salix* spp.) and cottonwood (*Populus* spp.), large beds of submerged aquatic vegetation, and emergent marsh habitat. Therefore, One-Mile Pond was expected to represent the range of fish species and habitat complexity found throughout the Oroville Wildlife Area ponds. Additionally, there are fishes in One-Mile Pond year-round (DWR 2002).

1.1.2.1 Description

Oroville Wildlife Area

The Oroville Wildlife Area (OWA) is approximately 11,800 acres in size and stretches for approximately 9.5 miles along the banks of the Feather River starting about two miles below the City of Oroville. The OWA contains over 75 warm water ponds and sloughs, along with vast complexes of emergent marsh and flooded cottonwood, willow, and sycamore (*Platanus* spp.) trees. The OWA ponds potentially provide habitat for a variety of fish species. However, due to the relatively warm water temperatures in the OWA ponds, the ponds primarily provide habitat for warm water fish.

As a group, the OWA ponds comprise a dynamic environment influenced by rainwater and river stage. Some ponds are permanently inundated, while others are inundated only seasonally. Levees along the Feather River keep most water from the main river channel from entering the OWA, except during high flow events. During these events, water from the main river channel spills over low spots in the levees, flooding large areas of the OWA for a period of time. The levee system in the OWA was designed to allow high flows to spill into the OWA as a flood control mechanism that disperses portions of the high flows moving down the main channel of the Feather River. Other than these high water events, OWA ponds are replenished by rainwater and underground seepage from the water table, which is strongly affected by the stage of the Feather River. Therefore, water levels in OWA ponds fluctuate with changes in the amount of rain, the river stage, and the level of the water table. Large areas of the OWA flood seasonally during the winter and spring, and dry up during the late summer and fall with the lowering water table and river stage. The lowest elevation areas, such as the pits dug during historic dredging operations, remain flooded year-round, forming the permanent ponds that are common throughout the OWA (DWR 2001).

A significant habitat change continues to occur in the southeastern section of the OWA, representing about 1/3 of the total OWA acreage. Following a breach in the levee at approximately River Mile 60 that occurred during the 1997 floods, repairs were conducted that resulted in a small flow of water passing under the base of the levee and into the OWA on a continuous basis. Beaver dams have been constructed on this flow as it passes through the OWA, and large areas of the southeast section of the OWA are now flooded on a continuous basis, and are no longer subject to the fluctuation effects of the river stage and water table. Due to the lack of water level fluctuation in the area, aquatic vegetation encroachment has occurred. The increased plant growth in the OWA reportedly continues to decrease the amount of habitat suitable for foraging adult fish (DWR 2001).

Because many of the ponds in the OWA are hydrologically connected during months of high rainfall and high flows, and all have similar characteristics with respect to substrate and vegetation, One-mile Pond was chosen as a representative pond on which to base an analysis of habitat availability. Additionally, there are fish in One-Mile Pond year round (DWR 2002). Therefore, for the purposes of this evaluation, the fish habitat available in One-Mile Pond is assumed to represent the habitat available in all of the fish-bearing ponds in the OWA.

One-Mile Pond

One-Mile Pond is a large pond that contains a variety of habitat types that, for the purposes of this study, represent other fish-bearing ponds in the Oroville Wildlife Area. The water level in One-Mile Pond fluctuates with changes in river stage, making One-Mile Pond an Oroville Wildlife Area pond that is directly influenced by project operations. Under high flow conditions, One-Mile Pond is connected to other ponds in the Oroville Wildlife Area allowing fish to move freely between the ponds (DWR 2002).

Currently One-Mile Pond has approximately 96 acres of surface area, of which approximately 41.3 acres, or approximately 43 percent, are covered with shallow submergent or emergent vegetation. Submergent vegetation in the pond consists of coontail (*Ceratophyllum demersum*), Eurasian milfoil *(Myriophyllu spicatum*), and Canadian waterweed (*Elodea canadensis*) that forms dense subsurface mats. In some areas of the pond, the submergent plants are tall and grow almost to the surface of the pond. In other areas the dense mats of vegetation are three meters or more below the surface.

The southwest side of One-mile Pond consists of an open marsh area with pockets of open water, emergent vegetation, riparian shrubs, and riparian woodland. The emergent vegetation consists of pockets of four angled spikerush (*Eleocharis quadrangulata*), cattails (*Typha* spp.), bulrush (*Scirpus* spp.), and water primrose (*Ludwigia plepoides peploides*). Approximately 36 acres of emergent wetland were mapped in the southwest portion of the pond (pers. com., G. Kuenster, 2003).

1.1.2.2 History

The history of One-Mile Pond is tied to the resurgence of gold mining in the Oroville area, in approximately 1890, with the development of river dredging. Gold dredging along the Feather River transformed Oroville into the “mother dredging field of the state” (DWR 2001). From 1898 to 1916, Butte County was one of the most important gold-producing counties in California (DWR 2001). After 1916, the industry declined rapidly because the supply of gold in the area was exhausted. By 1930, dredging companies no longer found it possible to continue operations and moved out of the Oroville area (DWR 2001). The tailings of rocks and boulders remaining from the dredging operations were eventually put to use in the construction of the Oroville Dam during the early 1960s (DWR 2001).

The Oroville Wildlife Area is approximately 11,800 acres in size and stretches for approximately 9.5 miles along the banks of the Feather River starting about two miles below the City of Oroville. Fishing, hunting, nature study, and river-associated recreation are the primary activities at the OWA and is managed with a cooperative agreement between the DFG and DWR. The Department of Fish and Game (DFG) manages the portion of the Oroville Wildlife Area, east of the Thermalito Afterbay, of which One-Mile Pond is a part (DWR 2001).

In 1978, DFG developed a management plan for the Oroville Wildlife Area. The purpose of the plan was to provide for the preservation and enhancement of the Oroville Wildlife Area and for the reasonable enjoyment of the OWA by the public. In 1962, the Director of Water Resources declared that public interest required the acquisition of the Oroville Borrow Area (the clay source for the construction of Lake Oroville Dam) for fish and wildlife enhancement and recreation to be managed by DFG. On August 12, 1968, 5,500 acres was transferred to DFG for creation of the Oroville Wildlife Area (DWR 2001).

The 1978 management plan describes the purpose for the management of the OWA, provides a description of the area, the history of the site, potential concerns, and recommends action programs to address the concerns. One of the three primary objectives of the OWA, as stated in the management plan, is to provide for the recreational, scientific, and educational use of the area (DWR 2001).

1.2 DESCRIPTION OF FACILITIES

The Oroville Facilities were developed as part of the State Water Project (SWP), a water storage and delivery system of reservoirs, aqueducts, power plants, and pumping plants. The main purpose of the SWP is to store and distribute water to supplement the needs of urban and agricultural water users in northern California, the San Francisco Bay area, the San Joaquin Valley, and southern California. The Oroville Facilities are also operated for flood management, power generation, to improve water quality in the Delta, provide recreation, and enhance fish and wildlife.

FERC Project No. 2100 encompasses 41,100 acres and includes Oroville Dam and Reservoir, three power plants (Hyatt Pumping-Generating Plant, Thermalito Diversion Dam Power Plant, and Thermalito Pumping-Generating Plant), Thermalito Diversion Dam, the Feather River Fish Hatchery and Fish Barrier Dam, Thermalito Power Canal, Oroville Wildlife Area (OWA), Thermalito Forebay and Forebay Dam, Thermalito Afterbay and Afterbay Dam, and transmission lines, as well as a number of recreational facilities. An overview of these facilities is provided on Figure 1.2-1. The Oroville Dam, along with two small saddle dams, impounds Lake Oroville, a 3.5-million-acre-feet (maf) capacity storage reservoir with a surface area of 15,810 acres at its normal maximum operating level.

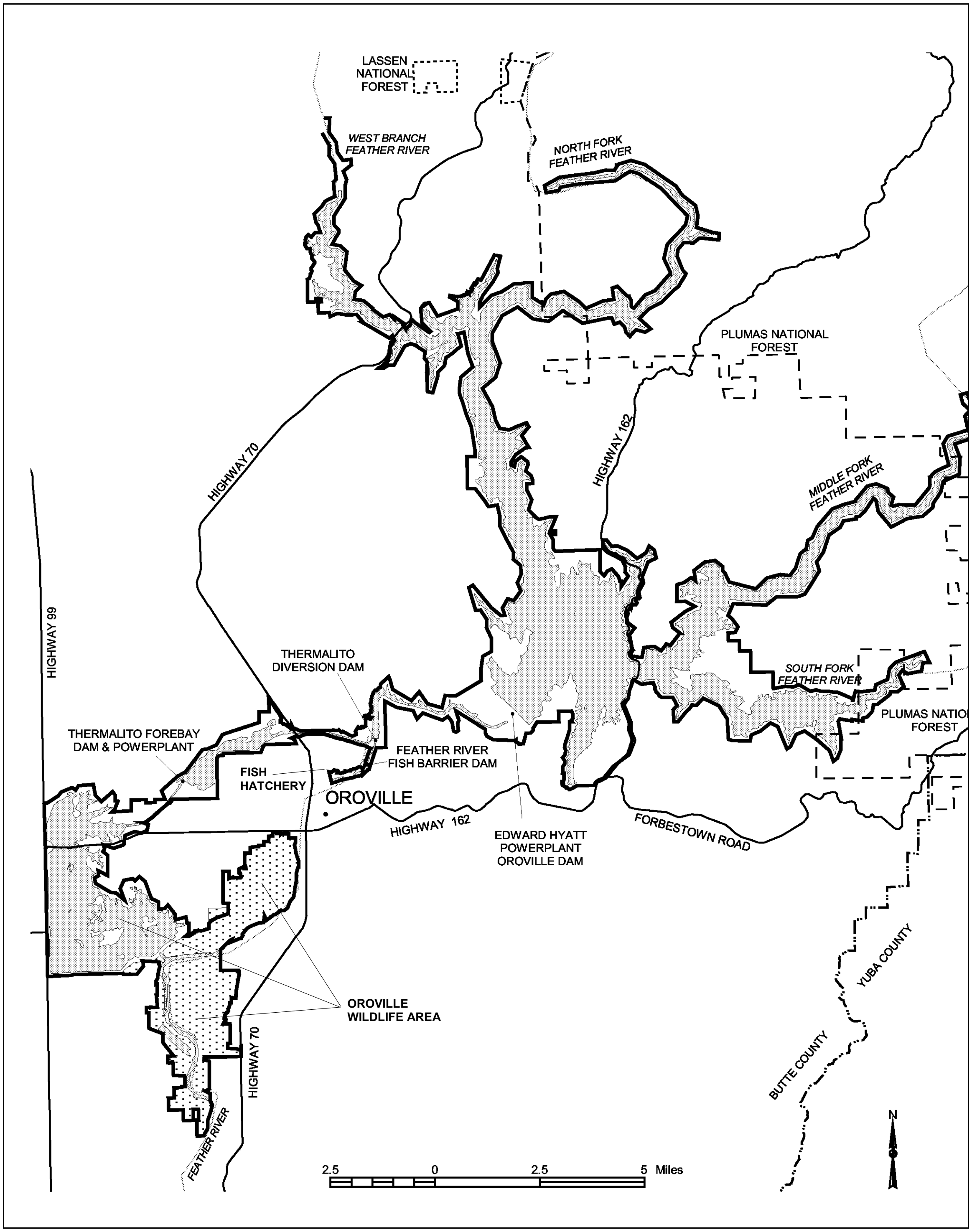

Figure 1.2-1. Oroville Facilities FERC Project Boundary.

The hydroelectric facilities have a combined licensed generating capacity of approximately 762 megawatts (MW). The Hyatt Pumping-Generating Plant is the largest of the three power plants with a capacity of 645 MW. Water from the six-unit underground power plant (three conventional generating and three pumping-generating units) is discharged through two tunnels into the Feather River just downstream of Oroville Dam. The plant has a generating and pumping flow capacity of 16,950 cfs and 5,610 cfs, respectively. Other generation facilities include the 3-MW Thermalito Diversion Dam Power Plant and the 114-MW Thermalito Pumping-Generating Plant.

Thermalito Diversion Dam, four miles downstream of the Oroville Dam creates a tail water pool for the Hyatt Pumping-Generating Plant and is used to divert water to the Thermalito Power Canal. The Thermalito Diversion Dam Power Plant is a 3-MW power plant located on the left abutment of the Diversion Dam. The power plant releases a maximum of 615 cubic feet per second (cfs) of water into the river.

The Power Canal is a 10,000-foot-long channel designed to convey generating flows of 16,900 cfs to the Thermalito Forebay and pump-back flows to the Hyatt Pumping-Generating Plant. The Thermalito Forebay is an off-stream regulating reservoir for the 114-MW Thermalito Pumping-Generating Plant. The Thermalito Pumping-Generating Plant is designed to operate in tandem with the Hyatt Pumping-Generating Plant and has generating and pump-back flow capacities of 17,400 cfs and 9,120 cfs, respectively. When in generating mode, the Thermalito Pumping-Generating Plant discharges into the Thermalito Afterbay, which is contained by a 42,000-foot-long earth-fill dam. The Afterbay is used to release water into the Feather River downstream of the Oroville Facilities, helps regulate the power system, provides storage for pump-back operations, and provides recreational opportunities. Several local irrigation districts receive water from the Afterbay.

The Feather River Fish Barrier Dam is downstream of the Thermalito Diversion Dam and immediately upstream of the Feather River Fish Hatchery. The flow over the dam maintains fish habitat in the low-flow channel of the Feather River between the dam and the Afterbay outlet, and provides attraction flow for the hatchery. The hatchery was intended to compensate for spawning grounds lost to returning salmon and steelhead trout from the construction of Oroville Dam. The hatchery can accommodate an average of 15,000 to 20,000 adult fish annually.

The Oroville Facilities support a wide variety of recreational opportunities. They include: boating (several types), fishing (several types), fully developed and primitive camping (including boat-in and floating sites), picnicking, swimming, horseback riding, hiking, off-road bicycle riding, wildlife watching, hunting, and visitor information sites with cultural and informational displays about the developed facilities and the natural environment. There are major recreation facilities at Loafer Creek, Bidwell Canyon, the Spillway, North and South Thermalito Forebay, and Lime Saddle. Lake Oroville has two full-service marinas, five car-top boat launch ramps, ten floating campsites, and seven dispersed floating toilets. There are also recreation facilities at the Visitor Center and the OWA.

The OWA comprises approximately 11,000-acres west of Oroville that is managed for wildlife habitat and recreational activities. It includes the Thermalito Afterbay and surrounding lands (approximately 6,000 acres) along with 5,000 acres adjoining the Feather River. The 5,000 acre area straddles 12 miles of the Feather River, which includes willow and cottonwood lined ponds, islands, and channels. Recreation areas include dispersed recreation (hunting, fishing, and bird watching), plus recreation at developed sites, including Monument Hill day use area, model airplane grounds, three boat launches on the Afterbay and two on the river, and two primitive camping areas. California Department of Fish and Game's (DFG) habitat enhancement program includes a wood duck nest-box program and dry land farming for nesting cover and improved wildlife forage. Limited gravel extraction also occurs in a number of locations.

1.3 CURRENT OPERATIONAL CONSTRAINTS

Operation of the Oroville Facilities varies seasonally, weekly and hourly, depending on hydrology and the objectives DWR is trying to meet. Typically, releases to the Feather River are managed to conserve water while meeting a variety of water delivery requirements, including flow, temperature, fisheries, recreation, diversion and water quality. Lake Oroville stores winter and spring runoff for release to the Feather River as necessary for project purposes. Meeting the water supply objectives of the SWP has always been the primary consideration for determining Oroville Facilities operation (within the regulatory constraints specified for flood control, in-stream fisheries, and downstream uses). Power production is scheduled within the boundaries specified by the water operations criteria noted above. Annual operations' planning is conducted for multi-year carry over. The current methodology is to retain half of the Lake Oroville storage above a specific level for subsequent years. Currently, that level has been established at 1,000,000 acre-feet (af); however, this does not limit draw down of the reservoir below that level. If hydrology is drier than expected or requirements greater than expected, additional water would be released from Lake Oroville. The operations plan is updated regularly to reflect changes in hydrology and downstream operations. Typically, Lake Oroville is filled to its maximum annual level of up to 900 feet above mean sea level (msl) in June and then can be lowered as necessary to meet downstream requirements, to its minimum level in December or January. During drier years, the lake may be drawn down more and may not fill to the desired levels the following spring. Project operations are directly constrained by downstream operational constraints and flood management criteria as described below.

1.3.1 Downstream Operation

An August 1983 agreement between DWR and DFG entitled, "Agreement Concerning the Operation of the Oroville Division of the State Water Project for Management of Fish & Wildlife," sets criteria and objectives for flow and temperatures in the low flow channel and the reach of the Feather River between Thermalito Afterbay and Verona. This agreement: (1) establishes minimum flows between Thermalito Afterbay Outlet and Verona which vary by water year type; (2) requires flow changes under 2,500 cfs to be reduced by no more than 200 cfs during any 24-hour period, except for flood management, failures, etc.; (3) requires flow stability during the peak of the fall-run Chinook spawning season; and (4) sets an objective of suitable temperature conditions during the fall months for salmon and during the later spring/summer for shad and striped bass.

1.3.1.1 Instream Flow Requirements

The Oroville Facilities are operated to meet minimum flows in the Lower Feather River as established by the 1983 agreement (see above). The agreement specifies that Oroville Facilities release a minimum of 600 cfs into the Feather River from the Thermalito Diversion Dam for fisheries purposes. This is the total volume of flows from the diversion dam outlet, diversion dam power plant, and the Feather River Fish Hatchery pipeline.

Generally, the instream flow requirements below Thermalito Afterbay are 1,700 cfs from October through March, and 1,000 cfs from April through September. However, if runoff for the previous April through July period is less than 1,942,000 af (i.e., the 1911-1960 mean unimpaired runoff near Oroville), the minimum flow can be reduced to 1,200 cfs from October to February, and 1,000 cfs for March. A maximum flow of 2,500 cfs is maintained from October 15 through November 30 to prevent spawning in overbank areas that might become de-watered.

1.3.1.2 Water Temperature Requirements

The Diversion Pool provides the water supply for the Feather River Fish Hatchery. The hatchery objectives are 52°F for September, 51°F for October and November, 55°F for December through March, 51°F for April through May 15, 55°F for last half of May, 56°F for June 1-15, 60°F for June 16 through August 15, and 58°F for August 16-31. A temperature range of plus or minus 4°F is allowed for objectives, April through November.

There are several temperature objectives for the Feather River downstream of the Afterbay Outlet. During the fall months, after September 15, the temperatures must be suitable for fall-run Chinook. From May through August, they must be suitable for shad, striped bass, and other warmwater fish.

The National Marine Fisheries Service has also established an explicit criterion for steelhead trout and spring-run Chinook salmon. Memorialized in a biological opinion on the effects of the Central Valley Project and SWP on Central Valley spring-run Chinook and steelhead as a reasonable and prudent measure; DWR is required to control water temperature at Feather River mile 61.6 (Robinson's Riffle in the low-flow channel) from

June 1 through September 30. This measure requires water temperatures less than or equal to 65°F on a daily average. The requirement is not intended to preclude pump-back operations at the Oroville Facilities needed to assist the State of California with supplying energy during periods when the California ISO anticipates a Stage 2 or higher alert.

The hatchery and river water temperature objectives sometimes conflict with temperatures desired by agricultural diverters. Under existing agreements, DWR provides water for the Feather River Service Area (FRSA) contractors. The contractors claim a need for warmer water during spring and summer for rice germination and growth (i.e., 65°F from approximately April through mid May, and 59°F during the remainder of the growing season). There is no obligation for DWR to meet the rice water temperature goals. However, to the extent practical, DWR does use its operational flexibility to accommodate the FRSA contractor's temperature goals.

1.3.1.3 Water Diversions

Monthly irrigation diversions of up to 190,000 (July 2002) af are made from the Thermalito Complex during the May through August irrigation season. Total annual entitlement of the Butte and Sutter County agricultural users is approximately 1 maf. After meeting these local demands, flows into the lower Feather River continue into the Sacramento River and into the Sacramento-San Joaquin Delta. In the northwestern portion of the Delta, water is pumped into the North Bay Aqueduct. In the south Delta, water is diverted into Clifton Court Forebay where the water is stored until it is pumped into the California Aqueduct.

1.3.1.4 Water Quality

Flows through the Delta are maintained to meet Bay-Delta water quality standards arising from DWR's water rights permits. These standards are designed to meet several water quality objectives such as salinity, Delta outflow, river flows, and export limits. The purpose of these objectives is to attain the highest water quality, which is reasonable, considering all demands being made on the Bay-Delta waters. In particular, they protect a wide range of fish and wildlife including Chinook salmon, Delta smelt, striped bass, and the habitat of estuarine-dependent species.

1.3.2 Flood Management

The Oroville Facilities are an integral component of the flood management system for the Sacramento Valley. During the wintertime, the Oroville Facilities are operated under flood control requirements specified by the U.S. Army Corps of Engineers (USACE). Under these requirements, Lake Oroville is operated to maintain up to 750,000 af of storage space to allow for the capture of significant inflows. Flood control releases are based on the release schedule in the flood control diagram or the emergency spillway release diagram prepared by the USACE, whichever requires the greater release. Decisions regarding such releases are made in consultation with the USACE.

The flood control requirements are designed for multiple use of reservoir space. During times when flood management space is not required to accomplish flood management objectives, the reservoir space can be used for storing water. From October through March, the maximum allowable storage limit (point at which specific flood release would have to be made) varies from about 2.8 to 3.2 maf to ensure adequate space in Lake Oroville to handle flood flows. The actual encroachment demarcation is based on a wetness index, computed from accumulated basin precipitation. This allows higher levels in the reservoir when the prevailing hydrology is dry while maintaining adequate flood protection. When the wetness index is high in the basin (i.e., wetness in the watershed above Lake Oroville), the flood management space required is at its greatest amount to provide the necessary flood protection. From April through June, the maximum allowable storage limit is increased as the flooding potential decreases, which allows capture of the higher spring flows for use later in the year. During September, the maximum allowable storage decreases again to prepare for the next flood season. During flood events, actual storage may encroach into the flood reservation zone to prevent or minimize downstream flooding along the Feather River.

2.0 NEED FOR STUDY

As a subtask of SP-F3.1, *Evaluation of Project Effects on Fish and Their Habitat within Lake Oroville, its Upstream Tributaries, the Thermalito Complex, and the Oroville Wildlife Area*, Task 5B fulfills a portion of the FERC application requirements by characterizing fish habitat in One-Mile Pond. In addition to fulfilling statutory requirements, the conclusions from this analysis may be used as the basis for developing or evaluating potential Resource Actions focused on providing appropriate aquatic habitat in the Oroville Wildlife Area for management of a warm water fishery.

Performing this subtask is necessary, in part, because operations of the Oroville Facilities affect river stage in the Lower Feather River which, in turn, directly impact and influence in-river water temperature regimes, Oroville Wildlife Area ponds water replenishment, water temperature, and species complexity (DWR 2002).

Ongoing operation of the Oroville Facilities influences flows and water temperatures in the Feather River downstream of the Thermalito Diversion Dam. Water temperature is an important factor influencing the availability of habitat for various species of fish in the Oroville Wildlife Area and One-Mile Pond. Task 5 of SP-F3.1 describes fish species composition and characterizes habitat in the Oroville Wildlife Area ponds. Task 5A describes fish species composition in One-Mile Pond and Task 5B, evaluates and characterizes fish habitat available in One-Mile Pond.

3.0 STUDY OBJECTIVES

3.1 STUDY APPLICATION

The objective of SP-F3.1 Task 5B was to collect baseline habitat characterization information to serve as a foundation for future evaluations and development of potential Resource Actions designed to continue to provide an attractive fishery in the Oroville Wildlife Area ponds. Additionally, data collected in this task serves as a foundation for future evaluations and development of potential Resource Actions. One specific suggested Resource Action was the development and implementation of measures designed to reduce aquatic weed encroachment in the Oroville Wildlife Area, and therefore an evaluation of fish habitat in One-Mile Pond was necessary to provide the tools necessary to determine whether the Resource Action would be feasible or beneficial (DWR 2002).

3.1.1 Environmental Documentation

In addition to Section 4.51(f)(3) of 18 CFR, which requires reporting of certain types of information in the FERC application for license of major hydropower projects (FERC 2001), it may be necessary to satisfy the requirements of the National Environmental Policy Act (NEPA). Because FERC has the authority to grant an operating license to DWR for continued operation of the Oroville Facilities, discussion is required to identify the potential impacts of the project on many types of resources, including fish, wildlife, and botanical resources. In addition, NEPA requires discussion of any anticipated continuing impact from on-going and future operations. To satisfy NEPA, DWR is preparing a Preliminary Draft Environmental Assessment (PDEA) to attach to the FERC license application, which shall include information provided by this study plan report.

3.1.2 Settlement Agreement

In addition to statutory and regulatory requirements, SP-F3.1 Task 5B could provide information to aid in the development of potential Resource Actions to be negotiated during the collaborative process.

Also, information obtained from analysis of the availability of warm water habitat for a warm water fishery in the Oroville Wildlife Area could be used to determine operating procedures negotiated during the collaborative settlement process.

4.0 METHODOLOGY

4.1 STUDY DESIGN

SWRI performed a literature search to determine habitat conditions reported in the literature to be suitable for the species that could potentially be found in One-Mile Pond, as well as those species actually found in the pond during electrofishing efforts conducted by DWR.

The species that could potentially be found in One-Mile Pond include those warm water species that are routinely found in the lower Feather River below the Thermalito Afterbay Outlet, including four species of black bass (*Micropterus punctulatus*, *M. salmoides*, *M. dolomieu*, *M. coosae*), three species of sunfish (*Lepomis macrochirus*, *L. cyanellus*, and *L. microlophus*), and two species of crappie (*Pomoxis nigromaculatus*, and *P. annularis*) (DWR 2001). Additionally, other popular introduced sport fish, such as striped bass (*Morone saxatilis*) and American shad (*Alosa sapidissima*), can potentially be found in One-Mile Pond. Other introduced fish including common carp (*Cyprinus carpio*), wakasagi (*Hypomesus nipponensis*) and threadfin shad (*Dorosoma petenense*) as well as native fish such as Sacramento pikeminnow (*Ptychocheilus grandis*), hardhead (*Mylopharodon conocephalus*), Sacramento sucker (*Catostomus occidentalis*), Sacramento splittail (*Pogonichthys macrolepidotus*), river lamprey (*Lampetra ayresi*), Pacific Lamprey (*Lamptera tridentata*), tule perch (*Hysterocarpus traski*), green sturgeon, (*Acipenser medirostris*), and white sturgeon (*Acipenser transmontanus*) also could potentially occur within One-Mile Pond and adjacent OWA ponds (DWR 2002).

SWRI performed a habitat analysis on the species listed above because they can potentially be found in most of the OWA ponds due to the occasional connections with the Feather River.

In order to determine the suitability of One-Mile Pond as warmwater fish habitat, SWRI compared available water quality and vegetative cover data to water quality and vegetative cover parameters reported to be suitable, optimal, or preferred for the fish species that could potentially be found in the pond. Additionally, a habitat availability analysis was performed for species identified during electrofishing efforts conducted by DWR in One-Mile Pond.

Additionally, this study was designed to identify the fish species currently present in the OWA, as well as to generally describe their relative abundance. Because the OWA is comprised of dozens of individual ponds, as well as a complex of interconnected wetlands, it was not feasible to sample all of the waters of the area. Therefore, DWR and the EWG decided to sample a single OWA pond that represents the general habitat and hydrologic function of the entire area. One-Mile Pond was selected as representative of the OWA ponds.

One-Mile Pond is located on the west side of the Feather River about 3/4 mile south of the Vance Avenue entrance to the OWA. It contains the various habitat types found in the ponds of the OWA, such as a substrate and shoreline consisting of mostly cobble, seasonally flooded terrestrial vegetation such as willow and cottonwood species, large beds of submerged aquatic vegetation, and emergent marsh habitat. An additional pond that is locally known as “Robinson’s Pond”, located on the east side of the Feather River immediately adjacent to the OWA and Granite Construction property (formerly Robinson’s Construction), was also sampled for the presence of fish, and the fish species composition of “Robinson’s Pond” was included with One-Mile Pond to develop a more comprehensive list for habitat suitability assessment. Although Robinson’s Pond is not technically part of the OWA, its configuration, habitat, and close proximity to the OWA should allow comparisons to be made between it and the OWA ponds (pers. com., E. See, 2003).

4.1.1 DWR Methodology

4.1.1.1 Fish Species

The fish species composition for the OWA was determined from electrofishing efforts conducted on November 21, 2002, April 4, 2003 and June 10, 2003. One-mile Pond was sampled using two Smith-Root SR-18 electrofishing boats on November 21, 2002 and June 10, 2003, and all sampling occurred at night. Total lengths were measured for all fish captured, and the entire shoreline was sampled except for areas too shallow to operate the boats, or near locations being used by the public for fishing or other recreation. Anecdotal information, from hook and line sampling, direct observation, and angler interviews, were collected by DWR and DFG personnel and are identified in the study plan report produced to satisfy SP-F3.1 Task 5A *One-Mile Pond Fish Species Composition* (DWR 2003; pers. com., E. See, 2003).

One Smith Root SR-20EH was used to sample “Robinson’s Pond” on April 17, 2003. The primary goal was to collect tissue samples for the metals analysis for the study plan SP-W2. Therefore, not all sampled fish were taken into the boat and measured (DWR 2003; pers. com., E. See, 2003).

It should be noted that adult carp were observed on all sampling efforts, however they were rarely taken into the boats due to their disturbance potential inside the livewells with the other fish (pers. com., E. See, 2003).

In addition to analysis of habitat suitability for fish species found in the Feather River below the Thermalito Afterbay Outlet that are reported in DWR (2001) and DWR (2002), analysis of habitat suitability was performed on the following fish species, which were found during electrofishing efforts conducted in One-Mile Pond (DWR 2003; pers. com., E. See, 2003).

Family Cyprinidae

- Sacramento blackfish (*Orthodon microlepidotus*)
- Hardhead (*Mylopharodon conocephalus*)
- Golden shiner (*Notemigonus crysoleucus*)

Family Catostomidae

- Sacramento sucker (*Catostomus occidentalis*)

Family Cottidae

- Sculpin (*Cottus* sp)

Family Ictaluridae

- Brown bullhead (*Ameirius nebulosis*)

Family Centrarchidae

- Largemouth bass (*Micropterus salmoides*)
- Bluegill (*Lepomis macrochirus*)
- Green sunfish (*Lepomis cyanellus*)
- Redear sunfish (*Lepomis microlophus*)
- Warmouth (*Lepomis gulosus*)
- Black crappie (*Pomoxis nigromaculatus*)

4.1.1.2 Water Quality and Depth

Several times during the fall and spring of 2002 and 2003, DWR staff collected water temperature and dissolved oxygen concentration data in One-Mile Pond. DWR water quality staff collected three water quality and depth measurements on separate dates in June 2002. Two samples were collected on separate dates for the months of July through October, 2002. Each sampling date occurred one week apart. One sampling effort occurred each month from November, 2002 through May, 2003. In June, 2003 DWR staff collected three separate water quality samples and depth measurements using the same guidelines as June 2002 (early, middle and late portions of the month). Two sampling efforts occurred per month in July and August, 2003 (pers. com., R. Martin, 2003).

Water quality sampling efforts in One-Mile Pond consisted of measuring water temperatures and dissolved oxygen concentrations (mg/L), beginning at the surface and descending in one-half to one meter increments until reaching the bottom of the pond at the sample location (pers. com., R. Martin, 2003).

4.1.1.3 Vegetative Cover

DWR staff mapped vegetation within One-Mile Pond according to methods described in SP-T4, *Biodiversity, Vegetation Communities, and Wildlife Habitat Mapping*. Vegetation patterns were digitized from 2001 georeferenced aerial photographs (1:7200) using Arcview software. Both submergent and emergent vegetation were found in or around the pond. The main body of the pond (those areas of the pond mapped as open water) is approximately 96 acres in size (pers. com., G. Kuenster, 2003).

5.0 RESULTS

5.1 PLANT SPECIES COMPOSITION

Both emergent and submergent vegetation are found in and around One-Mile Pond. Submergent vegetation consists of coontail (*Ceratophyllum demersum*), Eurasian milfoil (*Myriophyllum spicatum*), and Canadian waterweed (*Elodea Canadensis*), which form dense subsurface mats. In places, the submerged rooted plants are tall and grow to just below the surface of the water, while in other places, the dense mats of vegetation are three meters or more below the surface. Approximately 43 percent of One-Mile Pond was mapped as containing submerged vegetation (pers. com., G. Kuenster, 2003).

The southwest side of One-Mile Pond consists of an open marsh area with pockets of open water, emergent vegetation, riparian shrubs, and riparian woodland. The emergent vegetation consists of pockets of four-angled spikerush, cattails, tules, and water primrose. Approximately 36 acres of emergent wetland were mapped in this area (pers. com., G. Kuenster, 2003).

5.2 FISH SPECIES AND HABITAT COMPOSITION

Water temperatures in One-Mile Pond ranged from a low of 9.9°C (49.8°F) from 1 to 4 meters below the surface on January 21, 2003, to as high as 31.8°C (89.2°F) at the surface on July 24, 2003. Dissolved oxygen concentrations ranged from a low of 0.0 mg/L at 3.5 m below the surface at 2:30 PM on July 24, 2003 at a water temperature of 23.6°C (74.5°F) to a high dissolved oxygen concentration of 12.9 mg/L at one meter below surface at 5:45 PM on May 9, 2003 at a water temperature of 18.7°C (65.6°F) (pers. com., R. Martin, 2003)

The water depth of One-Mile Pond varies depending on the time of year and is generally between three meters and four and a half meters deep, but can be as shallow as two and a half meters deep (pers. com., R. Martin, 2003). Aquatic vegetative cover and substrate found in One-Mile Pond and the Oroville Wildlife Area were reported to be characterized by seasonally flooded terrestrial vegetation such as willow species, cottonwood and sycamore trees, large beds of submerged aquatic vegetation, and emergent marsh habitat with a cobbled bottom interspersed with boulders and sand, silt, and clay (DWR 2001; DWR 2002). Aquatic vegetation coverage within One-Mile Pond was reported to be approximately 43% (pers. com., G. Kuenster, 2003).

For all the native and introduced fish species included in this evaluation (SP-F3.1 Task 5B) the habitat suitability criteria reported in the literature for each fish species is compared to the water temperatures, dissolved oxygen concentrations, water depths, and aquatic vegetative cover in One-Mile Pond.

5.2.1 Native Fish Species

5.2.1.1 Cyprinidae

Sacramento pikeminnow (*Ptychocheilus grandis*)

Wang (1986) indicated that the water temperatures preferred by Sacramento pikeminnow during spawning were above 14.0°C (57.2°F) in the Sacramento – San Joaquin River System tributaries. Harvey (2002) reported that Sacramento pikeminnow also have been reported to reproduce in the largest, warmest tributaries within the Eel River drainage (Harvey et al. 2002). Moyle (2002) indicated that within the Sacramento – San Joaquin River system, Sacramento pikeminnow eggs have been reported to hatch in 4 to 7 days at a water temperature of 18.0°C (64.4°F). Harvey (2002) reported that the preferred range for rearing juvenile pikeminnow was 17.7°C (63.9ºF) to 24.5°C (76.1ºF) in the Eel River tributaries (Harvey et al. 2002). Moyle (2002) indicated that for adults, the preferred maximum water temperature within the Sacramento – San Joaquin River systems was reported to be “around 26.0°C (78.8°F)” while water temperatures above 38.0°C (100.4°F) were reported to be lethal. Additionally, Cech (1990) indicated that Sacramento pikeminnow were reported to show an increased sensitivity to low dissolved oxygen after an abrupt 5.0°C (41.0°F) water temperature increase at water temperatures between 10.0°C (50.0°F) and 25.0°C (77.0°F) (Cech Jr. et al. 1990).

Moyle (2002) reported that the preferred spawning substrate of Sacramento pikeminnow within the Sacramento River system was gravel within riffles or shallow flowing areas at the base of pools. Patten and Rodman (1969) indicated that the preferred spawning depths were reported to be from 5 cm to 20 cm, as observed within Merwin Reservoir. Additionally, it has been reported by Gadomski (2001) that various studies have shown that cyprinid larvae prefer shallow, low velocity vegetated habitats (Gadomski et al. 2001). Brown and Moyle (1997) reported that juveniles were observed most often using pools within the Van Duzen River. Brown and Moyle (1991) indicated that the depth range within the Eel River reported to be utilized by adult pikeminnow was 44 cm to 115 cm. Later studies by Brown and Moyle reported that the depth preference within the Eel River was 45 cm (Brown and Moyle 1997). Harvey and Nakamoto (1999) reported that others found that 28 cm was the preferred depth for adult pikeminnow within the Eel River tributaries.

The water temperatures, depths and vegetative cover within One-Mile Pond fall within the ranges reported by various authors to be within the tolerance ranges of Sacramento pikeminnow. Therefore, suitable habitat exists within the pond for Sacramento pikeminnow.

Hardhead (*Mylopharodon conocephalus*)

Wang (1986) reported that the preferred water temperature range for spawning hardhead is 15.0°C to 18.0°C (59.0-64.4°F). Moyle (1995) indicated that little literature exists to support identification of index water temperatures for incubation, early development and juvenile rearing. Moyle (1995) indicated that adults, however, are reportedly found in streams that have average summer water temperatures greater than 20.0°C (68.0°F). Moyle (2002) reported that the preferred water temperature, in laboratory conditions, was between 24.0°C and 28.0°C (75.2-82.4°F). Like many species, hardhead are reported to be relatively intolerant of low oxygen levels at high water temperatures (Moyle 2002).

Moyle (2002) indicated that hardhead spawning nests were reportedly constructed in gravel in riffles, runs, or at the heads of pools. After hatching, the larval and post larval fish were reported to remain along stream edges in dense cover of flooded vegetation or fallen tree branches. As they grow they move into deeper areas. Small juveniles may concentrate along the edges of rivers and ponds among large cobbles and boulders. Moyle (2002) reported that at 2 cm to 5 cm, juveniles begin to select habitats similar those of adults. Adults were reported to be found in the deep, slow moving pools of rivers and streams (Page and Burr 1991). Additionally, Moyle (2002) reported that adults often remain in the lower half of the water column, although in reservoirs they can be occasionally be seen hovering close to the surface. Cooper (1983) indicated that the preferred substrate was sand, gravel, and boulders.

Cover, water temperature, and substrate types that are found within One-Mile Pond correspond to those reported to be suitable for larval, juvenile, and adult hardhead lifestages. Spawning habitat likely does not exist due the species reported preference for gravel in relatively fast moving habitats such riffles, runs, and the heads of pools.

<u>Sacramento splittail (*Pogonitchthys macrolepidotus*)</u>

Moyle (2002) reported that the onset of spawning has been associated with increasing water temperatures between 14.0°C and 19.0°C (57.2-66.2°F). Caywood (1974) indicated that other studies reported that the water temperature preference for spawning was between 9.0°C and 20.0°C (48.2-68.0°F). In a laboratory study, Young et al. (1996), showed that juvenile splittail tolerated minimum water temperatures between 6.5°C and 7.3°C (44.1-45.1°F) and maximum water temperatures between 20.5°C and 33.0°C (68.9-91.4°F) depending on acclimation temperature and age (study tested age 0 through age 2). Moyle (2002) reported that adult splittail are found at water temperatures between 5.0°C and 24.0°C (41.0°F and 75.2°F). However, Moyle (2002) reported fish acclimated to high water temperatures can survive rapid water temperature changes and maximum water temperatures between 29.0°C and 33.0°C (84.2°F-91.4°F) for short periods. Moyle (2002) indicated all size classes of Sacramento splittail can survive less than 1 mg/L dissolved oxygen concentration.

Wang (1986) reported that spawning occurs in flooded riverbeds and submerged vegetation in flooded areas (U.S. Fish and Wildlife Service 2003). Meng and Moyle (2002) reported after hatching, larvae remain in shallow, weedy areas until the water recedes, and then they migrate downstream. Juvenile rearing was reported by Meng and Moyle (2002) to occur in shallow-water habitat with emergent vegetation (i.e., bulrushes and reeds). The reported depth preference for adult splittail was less than or equal to 22 ft (less than or equal to 6.7 m) (Meng and Moyle 1995). In addition, preferred habitat was reported to include shallow dead-end sloughs of the marsh, lined with bulrushes and reeds providing rich feeding grounds and refuge from predators (Meng and Moyle 1995).

Based on the available literature, adequate cover, water temperatures, and dissolved oxygen concentrations exist within the portions of One-Mile Pond that were sampled to allow splittail to inhabit the pond. During electrofishing activities, however, no Sacramento Splittail were observed.

Sacramento blackfish (*Orthodon microlepidotus*)

Moyle (2002) reported the water temperature range in which spawning occurs was between 12°C and 24°C (53.6-75.2°F). Knight (1985) was reported by Moyle (2002) to have shown that juvenile blackfish in the laboratory could survive water temperatures up to 37°C (98.6°F). Moyle (2002) indicated adult blackfish were commonly found in waters where water temperatures exceeded 30°C (86.0°F) and where dissolved oxygen concentrations were potentially very low. Moyle (2002) reported the preferred water temperatures of adult blackfish ranged from 22°C to 28°C (71.6-82.4°C), although growth rates were reported by Moyle (2002) to be reduced at water temperatures above 25°C (77.0°F). Sacramento blackfish are reported to have the ability to survive warm, turbid waters (Moyle 2002).

Moyle (2002) reported that spawning behavior has been observed over rocks and in areas with heavy aquatic plant growth in water less than 18 cm deep. Moyle (2002) indicated that fertilized eggs stick to the substrate, and larvae are often concentrated in shallow water, especially near or in beds of aquatic plants. Juvenile blackfish are reportedly typically found in large schools in shallow water, often near cover. Cech et al. (1982) were reported by Moyle (2002) to have found that they can live on plant material alone, but they grow fastest where animal prey is abundant (Moyle 2002).

Because Sacramento blackfish can reportedly tolerate a wide variety of habitat conditions including high water temperature, low dissolved oxygen concentration and have been observed spawning in a wide range of habitat conditions, it is expected that One-Mile Pond provides habitat for the species. Additionally, Sacramento blackfish were captured in One-Mile Pond during DWR electrofishing efforts.

5.2.1.2 Catostomidae

Sacramento sucker (*Catostomous occidentalis*)

Moyle (2002) reported that the water temperature range that Sacramento sucker spawning occurs is between 12.0°C and 18.0°C (53.6°F – 64.4°F). Although little information regarding incubation, early development, juvenile rearing, and adult water temperature preferences are unknown, Moyle (2002) reported that Sacramento sucker "are not particularly fussy when it comes to choosing water temperatures" (Moyle 2002). Moyle (2002) reported that Sacramento suckers are found in streams where water temperatures rarely exceed 15.0°C to 16.0°C (59.0-60.8°F), and in streams where water temperatures may reach 29.0°C to 30.0°C (82.4-86.0°F). Moyle (2002) suggested that preferred water temperatures fell between 20.0°C and 25.0°C (68.0-77.0°F), which may be optimal for growth. Little information is available on suitable, preferred, or optimal dissolved oxygen concentrations for Sacramento sucker.

The preferred spawning substrate of Sacramento sucker was reported to be sand, gravel, and cobble (Wang 1986). Newly hatched larvae usually remain within the interstices of the spawning gravel until the yolk sac is absorbed (Wang 1986). Juvenile rearing reportedly occurs in shallow areas, and larval suckers less than 14 mm SL concentrate over detritus or among emergent vegetation in warm, protected stream margins (Moyle 2002). Sacramento suckers are reportedly found in a wide variety of water from cold, rapidly flowing streams to warm sloughs of low salinity sections of the San Francisco Estuary. However, Sacramento suckers are reportedly most abundant in clear, cool streams and rivers and in lakes and reservoirs at moderate elevations (Moyle 2002).

Because Sacramento sucker are reported to be tolerant of a wide range of habitat conditions it is likely that One-Mile Pond provides suitable habitat for the species. Additionally, Sacramento sucker were observed utilizing One-Mile Pond during DWR electrofishing activities.

5.2.1.3 Petromyzontidae

River Lamprey (*Lampetra ayresi*)

Wang (1986) reported that the water temperature range that river lamprey spawn is between 13.0°C and 13.5°C (55.4-56.3°F). There is little information on water temperature preferences and dissolved oxygen concentration tolerances for incubation, early development, juvenile, and adult lifestages of river lamprey (Moyle 2002).

Spawning substrate was reported to range from rocks to gravel (Wang 1986), but preferred spawning habitat was reported to be gravel within riffles (Moyle 2002). Early developing river lamprey in the form of ammocoetes burrow into sandy or muddy substrates near the banks of rivers (Wang 1986). Juvenile cover preference is reported to be silty backwaters and eddies (Moyle 2002). Freshwater adults are free swimming throughout the water column (Wang 1986).

Seasonally, cover for juvenile river lamprey (silty backwaters) may exist within One-Mile Pond. Because little is reported in available literature about freshwater habitat characteristics for adult river lamprey it is unknown whether suitable habitat exists within

One-Mile Pond. Therefore, suitable habitat for juvenile and adult river lamprey may potentially seasonally inhabit One-Mile Pond. However, no lampreys were observed in One-Mile Pond during electrofishing efforts. Spawning is not likely to occur in One-Mile Pond due to the species' reported preference for riffles as spawning habitat.

Pacific lamprey (*Lampetra tridentata*)

Moyle (2002) reported that the water temperature range that Pacific lamprey spawn is between 12°C and 18°C (53.6-64.4°F). Water temperatures tolerated for incubation ranged from 10.0°C to 18.0°C (50-64.4°F) in laboratory conditions. Meeuwig et al. (2002) reported that at 22.0°C (71.6°F) survival dropped significantly for both incubation and juvenile rearing. Moyle (2002) reported that the preferred water temperature for incubation and early development is 15.0°C (59.0°F). Little information exists regarding water temperature preferences and tolerances for adult Pacific lamprey.

The substrate preferred for spawning was reported to be gravel (Moyle 2002). Generally, spawning reportedly occurs on sand and gravel in moderate to swift currents (lotic environment), but adult Pacific lamprey were observed to spawn in stagnant and muddy environments (lentic environment) (Whyte et al. 1993). Hatching ammocoetes are reported to spend a short time in nest gravel, eventually swimming up into the current where they are washed downstream to an area of soft sand and mud (Moyle 2002). Larvae burrow into soft sediments in shallow areas along the stream banks (Close 2001). Metamorphosing lamprey move from muddy habitat in lentic waters to habitats with silt covered large gravel (1-4 cm diameter) and moderate currents (Beamish 1980). The preferred median depth for holding adults was reported to be 0.9 m (Bayer et al. 2001). Immature Pacific lamprey were reported to hide in stones and logs for several months to a year until fully mature (Moyle 2002).

Because Pacific lamprey were reported to prefer low water temperatures during some lifestages it is unlikely that suitable habitat exists within One-Mile Pond year round. However, it is possible that suitable habitat exists during some times of the year. During electrofishing activities, however, no Pacific lamprey were observed.

5.2.1.4 Embiotocidae

Tule perch (*Hysterocarpus traski*)

Wang (1986) reported that Tule perch give birth when water temperatures are between 18.0°C and 20.0°C (64.4-68.0°F). However, little is known about water temperature preference for early development and juvenile rearing. Moyle (2002) reported that the water temperature preference for adult tule perch is lower than 22.0°C (71.6°F), and adults are not generally found in areas with water temperatures greater than 25.0°C (77.0°F). According to Moyle (2002) tule perch generally require cool, well-oxygenated water.

Wang (1986) reported that Tule perch spawn among tule marshes and other types of emergent vegetation. Torres (2002) indicated that adults are reported to prefer mud to gravel bottomed pools and runs of small to large, and low elevation rivers and lakes, usually near emergent plants or overhanging banks. In addition, Moyle (2002) found that beds of emergent aquatic plants, deep pools, and banks with complex cover, such as overhanging bushes, fallen trees and undercutting, and riprap, forage close to the bottom. Pregnant females reportedly are concealed in slower moving areas or backwaters with beds of aquatic plants, or with dense cover created by tree branches (Moyle 2002).

One-Mile Pond may constitute suitable habitat for tule perch during some parts of the year. When water temperatures increase during the summer months, it is unlikely that One-Mile Pond remains suitable for tule perch. During electrofishing efforts, no tule perch were observed in One-Mile Pond.

5.2.1.5 Acipenseridae

Green sturgeon (*Acipenser medirostris*)

DFG (2002) and Moyle (2002) reported that the water temperature that green sturgeon spawn is between 8.0°C and 14.0°C (46.4-57.2°F). However, DFG (2001) reported that the water temperature range for spawning is between 10.0°C and 21.1°C (50.0-70.0°F). The U.S. Fish and Wildlife Service (1995a) reported that the preferred water temperature for spawning is between 8.0°C and 14.0°C (46.4-57.2°F), somewhat colder than those reported for white sturgeon. Beamesderfer and Webb (2002) reported that water temperatures greater than 20.0°C (68°F) are lethal to embryos. The U.S. Fish and Wildlife Service (1995b) reported that adults in the Klamath River are found in water between 6.9°C and 16.0°C (44.4-60.8°F). Little information could be found regarding dissolved oxygen concentration requirements of green sturgeon.

The spawning substrate reportedly preferred by green sturgeon is large cobble, with crevices in which eggs become trapped and develop (Beamesderfer and Webb 2002). The preferred depth for spawning green sturgeon is reported to be any depth greater than nine feet (>2.7 m) in pools with relatively high velocities (U.S. Fish and Wildlife Service 1995). Larvae are reported to stay close to the substrate and rear in rivers upstream of estuaries. To avoid being transported downstream, green sturgeon larvae reportedly do not move up the water column until they become larger and stronger swimmers (DFG 2001).

One-Mile Pond could potentially provide suitable habitat for green sturgeon adults and juveniles during some times of the year. Because One-Mile Pond has relatively little flow under most conditions, it is unlikely to provide spawning habitat for green sturgeon. Additionally, green sturgeon were not observed during electrofishing efforts in One-Mile Pond.

<u>White sturgeon (*Acipenser transmontanus*)</u>

Parsley et al. (1993) and Kohlhorst (1976) reported that the water temperature ranges that white sturgeon spawn is from 10.0°C to 18.0°C (50.0-64.4°F) , and from 7.8°C to 17.8°C (46.0-64.0°F), respectively. Parsley (1993) and Kohlhorst (1976) reported that the preferred water temperatures for spawning are 14.0°C (57.2°F) and 14.4°C (57.9°F) respectively. Gadomski et al. (2002) reported that the optimal water temperature for spawning is 13.3°C (55.9°F). Parsley et al. (1993) reported that elevated mortality occurred among developing white sturgeon embryo's incubated at 18.0°C (64.4°F), and complete mortality occurred in embryos incubated at 20.0°C (68.0°F). Parsley et al. (1993) reported that the median water temperature at which spawning occurs is 14.0°C (57.2°F), and is equivalent to the water temperature identified as most suitable for white sturgeon egg development. Moyle (2002) reported that the preferred water temperature for white sturgeon juvenile rearing is 18.0°C (64.4°F). The water temperature range in which adult white sturgeon have been observed was reported to be between 0°C and 24.0°C (32-75.2°F) (Fishbase 2002). Little is known about the dissolved oxygen concentration requirements of white sturgeon.

The range of substrate over which adult white sturgeon have been reported to spawn is characterized by cobble and boulders, but some sturgeon reportedly also were found spawning over sand, gravel and bedrock (Parsley et al. 1993). White sturgeon spawning was also reported to take place over deep gravel riffles or in deep holes with swift currents and rock bottoms (Moyle 2002). The depth range preferred for spawning was reported to be between four meters and 24 meters (Parsley et al. 1993). Newly hatched larvae have been observed swimming towards the surface and remaining in the water column for a length of time that was inversely related to water velocity. The larvae were then observed seeking cover in or on the substrate and were reported to appear to be photophobic (Parsley et al. 1993). Parsley (1993) reported that the hiding phase exhibited by juveniles lasted until the yolk was absorbed (12 days after hatch). Additionally, juvenile white sturgeon were reported to prefer cover within the thalweg (deepest part) of the river or stream channel (Parsley et al. 1993). Adults have been observed at depths between 2 and 30 meters (Counihan et al. 1998). White sturgeon adults are reported to reside in shallower water during periods of high activity (summer) and deeper water in the winter (Brannon and Sutter 1992). Sites where white sturgeon showed the highest residence times had substrates consisting of mostly very fine sediment (Brannon and Sutter 1992).

Habitat suitable for some life stages of white sturgeon potentially exists in One-Mile Pond during portions of the year. It is unlikely, however, that habitat exists for rearing juvenile white sturgeon due to a lack of swift moving water. White sturgeon were not observed during electrofishing efforts in One-Mile Pond.

5.2.1.6 Cottidae

Sculpins are reportedly difficult to identify (Moyle 2002). Eight species of the genus *Cottus* live in California streams, and it is reportedly common to find two or three species living together (Moyle 2002). Sculpin were observed during electrofishing efforts in One-Mile Pond. Individual fish were not identified to the species level, however. During the literature review two species with overlapping ranges in the Sacramento Valley were identified as possible sculpin species present in the Oroville Wildlife Area.

Prickly sculpin (*Cottus gulosus*)

Suitable water temperatures for spawning prickly sculpin were reported by Kresja (1965, 1970) in Moyle (2002) to range from 8°C to 13°C (46.4-55.4°F). Prickly sculpin reportedly live in a wide variety of environments ranging from fresh water to sea water, and have been observed in streams ranging from small, cold, and clear streams to large, eutrophic and mesotrophic rivers (Moyle 2002). Moyle (2002) reported that Bond (1963) and Smith (1982) found prickly sculpin in lowland rivers where they might experience summer water temperatures between 28°C and 30°C (82.4-86.0°F).

Suitable spawning habitat for prickly sculpin reportedly includes areas in flowing water with loose rocks, under which males can locate nests, spawn, and guard incubating embryos (Moyle 2002). After hatching, larvae reportedly swim up into the water column to feed (Moyle 2002). Juveniles reportedly settle on and near the bottom, and move into areas with abundant food and cover (Moyle 2002). In the Central Valley, prickly sculpin reportedly are typically found in moderate-sized, clear, low elevation streams with substrates of rubble, sand, and scattered logs and boulders (Moyle 2002). Brown (2000) reported in Moyle (2002) that their absence from warm, polluted habitats of the San Joaquin Valley floor indicated that water quality limits distribution, because they are found in streams above the valley floor and in the estuary below it (Moyle 2002). In inland waters prickly sculpin may co-occur with riffle sculpin (Moyle 2002). Moyle (2002) also indicated that prickly sculpin spend most of their time quietly on the bottom. During the day they reportedly hide underneath submerged objects such as rocks, logs, and pieces of trash (Moyle 2002). White and Harvey (1999) indicated adult prickly sculpin in the Smith River (Del Norte County, CA) largely occupy deep (2-14 m), rock-bottomed pools, while coast range sculpins occupy riffles less than 1 m deep (Moyle 2002).

Because prickly sculpin have wide tolerance ranges for water temperature and substrate as well as a reported tolerance of eutrophic water bodies, it is likely that suitable habitat for the species exists within One-Mile Pond. Additionally, sculpin were observed during electrofishing efforts in the pond.

Riffle sculpin (*Cottus asper*)

Riffle sculpin reportedly spawn in late February, March, and April (Moyle 2002). According to Moyle (2002), Bond (1973) and Millikan (1968) reported that riffle sculpins spawn either on the underside of rocks in swift riffles or inside cavities of submerged logs (Moyle 2002). Additionally, Moyle (2002) reported that Baltz et al. (1982) and Cech et al. (1990) observed that riffle sculpin were most abundant in water that does not exceed 25°C to 26°C (77.0-78.8°F) for extended periods of time. Moyle (2002) also reported that water temperatures over 30°C (86.0°F) were usually lethal.

In warmer reaches of rivers where riffle scuplin coexist with prickly sculpin, riffle scuplin tend to be replaced by prickly sculpins (Moyle 2002). Harvey (1986) reported in Moyle (2002) that when gold dredging disturbs a riffle and buries the loose rocks under which sculpin hide, riffle sculpin numbers are reduced (Moyle 2002). Also, Cech et al. (1990) reported that a key aspect of riffle sculpin habitat was maintaining oxygen levels at or near saturation, “a requirement that restricts them to flowing water (Moyle 2002)".

Because riffle sculpin are reported to require highly oxygenated water and are thus restricted to flowing water (Cech et al 1990 *in* Moyle 2002), it is unlikely that One-Mile Pond provides suitable habitat for the species.

5.2.2 Introduced Fish Species

5.2.2.1 Cyprinidae

Common carp (*Cyprinus carpio*)

Moyle (2002) reported that carp spawn during spring and early summer when water temperatures start to exceed 15.0°C (59.0°F), with highest activity being occurring between 19.0°C and 23.0°C (66.2-73.4°F). Moyle (2002) also reported that adult carp are most active when water temperatures are between 4°C and 24.0°C (39.2-75.2°F), however, they can withstand high water temperatures of 31.0°C to 36.0°C (87.8-96.8°F), depending on acclimation temperature. Juvenile carp reportedly prefer a water temperature around 24.0°C (75.2°F) (Moyle 2002). Additionally, carp were reported to be able to tolerate low dissolved oxygen concentrations of 0.5 to 3.0 parts per million (ppm) (Moyle 2002). Nakamura (1994) reported in Moyle (2002) that carp can survive in de-oxygenated water by gulping air at the surface and pumping an air-water mixture across their gills.

Spawning reportedly takes place near beds of aquatic plants, usually close to shore, in shallow weedy areas, and in recently flooded areas (Moyle 2002). Smith (1982) reported in Moyle (2002) that juveniles prefer deep pools, but will move into shallow water if there are dense beds of aquatic vegetation for cover (Moyle 2002). Adults are reported by Brown (2000) in Moyle (2002) to be most abundant in eutrophic lakes, reservoirs, and sloughs with silty bottoms and submergent and emergent aquatic vegetation, as well as in streams associated with turbid waters; deep permanent pools; high alkalinity; and soft bottoms (Moyle 2002).

Because common carp can reportedly withstand water temperatures from 4°C to 36°C (39.2-96.8°F), depending on acclimation temperatures, and can tolerate low dissolved oxygen concentrations, it is likely that suitable habitat exists in One-Mile Pond. Additionally, it should be noted that adult common carp were observed on all electrofishing sampling efforts in One-Mile Pond.

Golden Shiner (*Notemigonus crysoleucas*)

Moyle (2002) reported that golden shiner begin spawning when water temperatures reach approximately 20.0°C (68°F). Moyle (2002) indicated that Becker (1983) reported spawning occurring in water with temperatures as low as 14.0°C (57.2°F), but rarely in water with temperatures above 27.0°C (80.6°F). Becker (1983) reported that embryos hatch in 4-5 days at water temperatures at 24.0-27.0° (75.2-80.6°F) (Moyle 2002). Little information exists on water temperature preferences for juvenile and non-spawning adult golden shiner. Smale and Rabeni (1995) reported that adult golden shiners could tolerate dissolved oxygen concentrations of less than one mg/L (Moyle 2002).

Becker (1983) reported in Moyle (2002) that female golden shiners deposit adhesive eggs on submerged vegetation and bottom debris (Moyle 2002). Additionally, Carlander (1969) reported in Moyle (2002) that occasionally, active nests of largemouth bass are selected as spawning sites. Newly hatched larvae remain on the bottom of the nesting area until the yolk sac is absorbed. Then, newly emerged fry reportedly school in large numbers close to shore, often in association with aquatic plants (Moyle 2002). Kisanuki (1980) reported in Moyle (2002) that golden shiners grow faster in warm waters than in cold waters (Moyle 2002). Little information exists on depth preferences of juvenile and adult golden shiner.

Because golden shiner reportedly spawn in warm water, and tolerate low dissolved oxygen concentrations, it is likely that One-Mile Pond provides suitable habitat for the species during most times of the year. Little is known about juvenile golden shiner water quality tolerance ranges, and so it is unclear whether habitat for juvenile golden shiner is present. Also, golden shiner were observed during electrofishing efforts in One-Mile Pond.

5.2.2.2 Osmeridae

Wakasagi (*Hypomesis nipponensis*)

In laboratory studies, the reported critical thermal maxima for wakasagi was between 27.0°C and 29.0°C (80.6-84.2°F), and the critical thermal minima was reported to be between 2.0°C and 4.5°C (35.6-40.1°F). The water temperature range between 14.0°C and 21.0°C (57.2-69.8°F) was reported by Moyle (2002) to probably be the most suitable for both growth and reproduction. Little information exists regarding wakasagi dissolved oxygen tolerance ranges.

The substrate preferred by wakasagi for spawning was reported to be sand and gravel. Free swimming juveniles reportedly colonize open waters of lakes and reservoirs where they grow quickly to adult size (Moyle 2002).

Because habitat characteristics, including water temperature, in One-Mile Pond fall within those tolerated and chosen by wakasagi, it is likely that suitable habitat within the pond exists for the species. However, during electrofishing efforts, wakasagi were not observed in One-Mile Pond.

5.2.2.3 Centrarchidae

Spotted bass (*Micropterus punctulatus*)

Moyle (2002) reported that spotted bass spawn at water temperatures rangeing between 15°C and 23°C (59.0 and 64.4 °F). Additionally, in California, Moyle (2002) reported spotted bass spawning at 14°C (57.2°F). Sammons et al. (1999) reported spotted bass hatching at water temperatures of 16.5°C to 20.0°C (61.7-68.0°F). Little is known about juvenile spotted bass water temperature tolerance ranges. Adults have been observed in areas where water temperatures range from 24.0°C to 31.0°C (75.2-87.8°F) during the summer (Moyle 2002). Coutant (1977) reported that Cherry et al. (1975) determined the water temperature preference in the laboratory of adult spotted bass. The results of the study indicated that adult spotted bass preferentially chose a water temperature of 32.5°C (90.5°F) (Coutant 1977). Little is known about the dissolved oxygen tolerance ranges of spotted bass.

Spawning substrate for spotted bass has been characterized as including large rocks, rubble and gravel (Aasen and Henry 1981; Moyle 2002). Spawning was reported to occur between 0.5 m and 4.6 m deep, with the most spawning occurring between 2.5 m and 3.0 m deep (Moyle 2002). Moyle (2002) reported that juveniles remain near shore in shallow water while young-of-year bass were found in small shoals. Moyle (2002) also reported that in streams, spotted bass adults are secretive pool dwellers, avoiding riffles and backwaters with heavy growths of aquatic plants. They reportedly prefer slower, more turbid waters than smallmouth bass, and faster water than largemouth bass (Moyle 2002). Spotted bass reportedly tend to congregate in water from one meter to four meters deep, and can often be found just above the thermocline in waters that stratify during the summer months. However, they reportedly tend to seek out deep water (30m to 40m) in reservoirs when water temperatures become uniform (Moyle 2002).

Based on reported habitat preferences and water quality tolerance ranges, habitat for spotted bass likely exists for all life stages within One-Mile Pond. However, no spotted bass were observed during electrofishing efforts in One-Mile Pond.

Largemouth bass (*Micropterus salmoides*)

Moyle (2002) reported that largemouth bass begin nest building at water temperatures between 15.0°C and 16.0°C (59.0-60.8°F), and spawning continues at water temperatures up to 24.0°C (75.2°F). Nesting success was reportedly reduced if water temperatures dropped below 15.5°C (59.9°F) (Lock and Davis 1997). At 20.0°C (68.0°F) and 23.0°C (73.4°F), dissolved oxygen concentrations as low as 35 percent saturation are reported to be adequate for embryo and larvae survival (Carlson and Siefert 1974). Juvenile rearing and growth occurs at water temperatures between 10.0°C and 35.0°C (50.0-95.0°F) (Moyle 2002). Juvenile largemouth bass, however, have been reported to prefer water temperatures of 30°C to 32°C (86-89.6°F) (Moyle 2002). Moyle (2002) reported, however, that adult largemouth bass preferred a water temperature of 27.0°C (80.6°F), while they can persist in water where temperatures reach 36.0°C to 37.0°C (96.8-98.6°F) during the day with dissolved oxygen concentrations as low as 1 mg/L (Moyle 2002).

Spawning has been reported to occur mostly over gravel, mud and sand substrates and in muddy areas below boulders (Wang 1986). In addition, spawning has been reported to occur next to submerged objects, such as logs or boulders (Moyle 2002). In California, Moyle (2002) reported that the range for spawning depth was 0.5 m to 2 m. However, in reservoirs with frequent or large fluctuations in water level, spawning can occur as deep as four to five meters (Moyle 2002). Juveniles stay close to shore in schools that cruise near or above beds of aquatic plants (Moyle 2002). The substrate preference for adults was reported to be beds of aquatic plants (Moyle 2002). In addition, largemouth bass can be found in farm ponds, lakes, reservoirs, sloughs, and river backwaters where other nonnative fish are abundant, and heavy growth of aquatic plants are present (Moyle 2002). The preferred depth for adults was reported to be less than 6 m and could be as shallow as 1-3 m (Moyle 2002).

Because largemouth bass can tolerate warm, densely vegetated waters with low dissolved oxygen concentrations, it is likely that One-Mile Pond provides suitable habitat for the species. Additionally, largemouth bass were observed during electrofishing efforts in One-Mile Pond.

Smallmouth bass (*Micropetus dolomieu*)

Graham and Orth (1986) reported that smallmouth bass spawn at water temperatures from 12.5°C to 23.5°C (54.5-74.3°F). Eggs are reported to hatch in 10 days at 12.8°C (55.0°F), and as rapidly as 2.5 days at 25.6°C (78.1°F) (Wang 1986). The reported water temperature preference for rearing juvenile smallmouth bass was 18.0°C (64.4°F) for young-of-year in the winter; 19.0°C to 24.0°C (66.2-75.2°F) for young-of-year in the spring; 31.0°C (87.8°F) for young-of-year in summer; and 24.0°C to 27.0°C (75.2-80.6°F) in fall. Adult smallmouth bass reportedly preferred water between 25.0°C and 27.0°C (77.0-80.6°F) (Moyle 2002). Dissolved oxygen concentrations in excess of 6.0 mg/L are reportedly needed for growth, while dissolved oxygen concentrations between 1 and 3 mg/L are reportedly adequate for survival (Moyle 2002).

The preferred spawning substrate of smallmouth bass reportedly consists of rubble, gravel, and sand near submerged logs, boulders, or other cover (Moyle 2002). Spawning was reported to take place in shallow water, between 0.5 meters and five meters deep (Moyle 2002). Newly hatched larva remain on the bottom of the nest for three to four days (Moyle 2002). Juvenile cover preference was reported to be sandy shoals and rocky areas (Wang 1986). The depth at which adult smallmouth bass were observed ranged from one to ten meters (Moyle 2002). Additionally, smallmouth bass are reported to concentrate in narrow bays or in areas along the shore where rocky shelves project under water (Moyle 2002).

Because smallmouth bass tolerate a wide range of water temperatures, low dissolved oxygen concentrations, and have been observed a wide range of depths, it is likely that suitable habitat for the species exists in the pond. However, no smallmouth bass were identified during electrofishing efforts in One-Mile Pond.

Redeye bass (*Micropterus coosae*)

Moyle (2002) reported that redeye bass spawn in water with temperatures ranging from 17.0°C to 21.0°C (62.6-69.8°F). The water temperature range for California streams during the summer in which redeye bass were found was reported to range from 26.0°C to 28.0°C (78.8-82.4°F) (Moyle 2002). Little information exists regarding dissolved oxygen concentration tolerances of redeye bass.

The spawning nest construction and parental behavior of redeye bass was reported to be similar to small mouth bass with males constructing nests in beds of gravel (Moyle 2002). Adults are reported to favor pools, and pockets of water near boulders and undercut banks (Moyle 2002). Little is known about depth preferences of redeye bass.

Because redeye bass life history characteristics are reportedly similar to those of smallmouth bass, it is likely that suitable habitat exists in One-Mile Pond for the species. However, no redeye bass were identified during electrofishing efforts.

Bluegill (*Lepomis macrochirus*)

Moyle (2002) reported that Bluegill spawn at water temperatures ranging from 18.0°C to 21.0°C (64.4-69.8°F). Eggs are reported to hatch in 2 to 3 days at 20.0°C (68.0°F) (Moyle 2002). The water temperatures reported by Neill (1971) in Coutant (1977) to be preferred by rearing bluegill in lab studies were 30.2°C (86.4°F) during the day and 31.5°C (88.7°F) during the night. Maximum growth and reproduction was reported to occur at dissolved oxygen concentrations between four mg/L and eight mg/L, although bluegill can survive dissolved oxygen concentrations that are less than one mg/L (Moyle 2002). Adults are reported to survive winter water temperatures as low as 2.0°C (35.6°F), and summer water temperatures as high as 41.0°C (105.8°F)(Moyle 2002).

Spawning nests were reported to have been constructed in substrates of gravel, sand, or mud that contain pieces of debris (Moyle 2002). In addition, Wang (1986) reported that nests were interspersed with debris in the form of twigs or dead leaves, sand or hard clay, and eggs were deposited on sticks or dead leaves (Wang 1986). Newly hatched larvae remain in the nesting area, while free swimming larvae inhabit shallow water with vegetation (Wang 1986). Adult males reportedly guard embryos during incubation and fry for about one week after hatching (Moyle 2002). Rearing juveniles swim in small schools near or among plant beds (Wang 1986). Adults reportedly prefer rooted aquatic plants such as cover in areas with substrates of silt, sand or gravel and with a preference for areas shallower than five meters (16.4 ft)(Moyle 2002).

Because bluegill reportedly tolerate a wide range of water temperatures and low dissolved oxygen concentrations, it is likely that suitable habitat for the species exists in One-Mile Pond. Additionally, bluegill were observed during electrofishing efforts in One-Mile Pond.

Green sunfish (*Lepomis cynellus*)

The reported water temperature range for spawning ranged from 15.0°C to 28.0°C (59.0-82.4°F) (Moyle 2002). In California, however, Moyle (2002) reports that spawning does not begin until water temperatures reach 19.0°C (66.2°F) (Moyle 2002). Laboratory studies indicated that green sunfish eggs hatched in 55 hours at 24°C (75.2°F) and took 35 hours to hatch at 27°C (80.6°F) (Taubert 1977). Juveniles given a choice in laboratory studies performed by Beittinger and others (1975) were reported by Coutant (1977) to prefer a water temperature of 28.2°C (82.8°F). Adults reportedly can survive water temperatures greater than 38.0°C (100.4°F) (Moyle 2002). In lab studies conducted by Cherry and others (1975) and later summarized by Coutant (1977), adults reportedly preferred a water temperature of 30.6°C (87.1°F). Green sunfish were reported to be able to withstand dissolved oxygen concentrations less than one mg/L (Moyle 2002).

Spawning substrate for green sunfish was characterized as consisting of gravel, clumps of vegetation or rock, often among the branches of fallen trees (Wang 1986). Others report the use of fine gravel substrate near overhanging bushes or other cover (Moyle 2002). Nests were reportedly constructed from four to 50 cm from the surface (Moyle 2002). The general habitat for rearing juveniles was reported as being mostly shallow, still or low velocity waters of the Sacramento-San Joaquin river system and small ponds with dense vegetation, ditches with filamentous algae, or inshore areas of large reservoirs (Wang 1986). The reported habitat preference for adults was characterized as being shallow with weedy areas, or generally areas with aquatic plant growth with muddy substrate. In addition, small, warm streams, or intermittent ponds and lake edges that contain more than three to four other species were reported to be utilized by adult green sunfish (Moyle 2002).

Because green sunfish reportedly utilize a wide variety of habitats and tolerate a wide range of water temperatures and low dissolved oxygen concentrations, it is likely that suitable habitat for the species exists in One-Mile Pond. Additionally, green sunfish were observed during electrofishing efforts in One-Mile Pond.

Redear sunfish (*Lepomis microlophus*)

The water temperature range at which spawning is reported to occur is between 21.0°C and 24.0°C (69.8-75.2°F). The depths at which spawning is reported to occur range from 0.5 m to six meters deep (Moyle 2002). Incubation and early development was reported to occur in water where temperatures reached up to 23.6°C (74.5°F). Little information exists on water temperature and dissolved oxygen concentration requirements and tolerance ranges for other redear sunfish lifestages.

The preferred spawning habitat for redear sunfish is reported to be gravel, sand, and hard clay within the shallow waters of ponds and reservoirs (Wang 1986). Larvae are planktonic at first, before settling into beds of aquatic plants (Moyle 2002). Juveniles were reported to stay close to or in aquatic plants beds, often in small shoals (Moyle 2002). Adult habitat is reported to be characterized by deeper waters of warm, quiet ponds, lakes and river backwaters and sloughs with substantial beds of aquatic vegetation (Moyle 2002).

Because redear sunfish are reported to utilize warm water habitats with abundant aquatic vegetation, it is likely that One-Mile Pond provides suitable habitat for the species. Additionally, redear sunfish were identified during electrofishing efforts in One-Mile Pond.

Warmouth (*Lepomis gulosus*)

Moyle (2002) reported that warmouth spawn in late spring and early summer when water temperatures reach about 21.0°C (69.8°F). Moyle (2002) also reported that there is little data on warmouth tolerances of environmental variables, but indicated that adults preferred water temperatures from 22.0°C to 28.0°C (71.6-82.4°F), and they can withstand dissolved oxygen levels under 4 mg/L in warm water. In addition, the species reportedly can live in fairly turbid waters (Moyle 2002).

Prior to spawning males reportedly build nests near dense cover, at depths of 0.5 meters to 1.5 meters. Most warmouth in California are reportedly found where there is abundant vegetation and other cover in warm, turbid, muddy-bottomed sloughs and backwaters of the Sacramento River (Moyle 2002). Moyle (2002) suggests that most of what is known about warmouth life history was from a study in Illinois conducted by Larimore (1957). However, little information is known about general depth utilization or preferences of juvenile and adult warmouth.

Because warmouth are reported to utilize warm water habitats with abundant aquatic vegetation, it is likely that One-Mile Pond provides suitable habitat for the species. Additionally, warmouth were identified during electrofishing efforts in One-Mile Pond.

Black Crappie (*Pomoxis nigromaculatus*)

The water temperature range at which black crappie spawn was reported as exceeding 14.0°C to 17.0°C (57.2-62.6°F), while the preferred water temperature range for spawning was reported to be between 18.0°C and 20.0°C (64.4-68.0°F) (Moyle 2002). Incubation was reported to take 2 to 3 days at 18.3°C (64.9°F) (Wang 1986). In lab studies, Coutant (1977) reported studies conducted by Neill (1971), which suggested that small individual juveniles were reported to tolerate water temperature ranges of 26.5°C to 30.0°C (79.7-86.0°F) during the day and 25.5°C to 29.5°C (77.9-85.1°F) at night(Coutant 1977). Other studies performed by Reutter and Herdendorf (1974) and reviewed by Coutant (1977), however, reported that the preferred water temperatures for adults were: 20.5°C (68.9°F) in winter, 21.0°C (69.8°F) in spring, 21.7°C (71.1°F) in summer, and 22.2°C (72.0°F) in fall. Little information exists describing the dissolved oxygen concentration tolerances of black crappie.

Spawning substrate was characterized as mud or gravel or beds of aquatic plants that reportedly occur in water less than one meter deep (Moyle 2002). Juveniles reportedly prefer quiet shallow water with patchy vegetation (Wang 1986). Little is known about the substrate and cover preference of resident adult black crappie.

Because black crappie are reported to utilize warm water habitats and spawn in a variety of substrates including aquatic vegetation, it is likely that One-Mile Pond provides suitable habitat for the species. Additionally, black crappie were identified during electrofishing efforts in One-Mile Pond.

White Crappie (*Pomoxis annularis*)

Moyle (2002) reported that white crappie spawn at water temperatures between 17.0°C and 20.0°C (62.6-68.0°F). Water temperatures reportedly tolerated during incubation ranged from 14.4°C to 22.8°C (57.9-73.0°F), while the preferred water temperature range was 18.9°C to 19.4°C (66.0-66.9°F) (Siefert 1968). In laboratory studies, performed by Reutter and Herdendorf (1974) and reviewed by Coutant (1977), water temperature preferences for adults were, 19.8°C (67.6°F) during winter; 18.3°C (64.9°F) during spring; and 10.4°C (50.7°F) during fall. Little information exists regarding dissolved oxygen concentration preferences of white crappie.

Nests for spawning are usually constructed by males in colonies underneath or close to overhanging bushes or banks in water less than one meter deep. Occasionally, nests are built in water as deep as six to seven meters. Nests usually consist of shallow depressions in hard clay, and rarely in sand or gravel, near or in beds of aquatic plants, algae, or submerged plant debris (Moyle 2002). Adults were reported to be littoral, living near the shore, and were most abundant in warm turbid lakes, reservoirs, and river backwaters (Moyle 2002). Little is known about the depth preferences of white crappie.

Because white crappie reportedly utilize similar habitat to black crappie and other sunfish species, it is likely that habitat exists for the species in One-Mile Pond. However, white crappie were not observed during electrofishing efforts.

5.2.2.4 Moronidae

Striped bass (*Morone saxatilis*)

Moyle (2002) reported that striped bass do not spawn when water temperatures are below 14.0°C (57.2°F) or above 21.0°C (69.8°F) within the Sacramento-San Joaquin River system. However, in some parts of California, striped bass were observed spawning when water temperatures were between 12.0°C and 22.0°C (53.6°-71.6°F) (SWRI 2002). Moyle (2002) reported that most striped bass spawning occurred in the Sacramento-San Joaquin River system, within the water temperature range of 15.0°C to 20.0°C (59-68°F). The reported water temperature range for striped bass incubation ranged from 16.0°C to 19.0°C (60.8-66.2°F), as observed within a variety of estuaries along the west coast (Emmett et al. 1991). In lab experiments performed by Meldrim and Gift (1971) and reviewed by Coutant (1977), the reported upper avoidance temperature of small juvenile individuals was 34.4°C (93.9°F). Water temperatures between 12.8°C and 23.9°C (55.0-75.0°F) were reported to be suitable for developing larvae and juveniles (SWRI 2002). Moyle (2002) reported that adults and juveniles within the Sacramento-San Joaquin River system were reported to be able to survive water temperatures as high as 34.0°C (93.2°F) for short periods of time. Stress levels are reported by Moyle (2002) to begin rising at water temperatures greater than 25.0°C (77.0°F), and water temperatures reportedly reach lethal levels beginning at 30.0°C (86.0°F). Moyle (2002) indicated that striped bass can reportedly withstand three to five mg/L dissolved oxygen concentrations for short periods, as observed within the Sacramento-San Joaquin River system (Moyle 2002). Five mg/L has been recommended as dissolved oxygen concentration for adequately maintaining a population of striped bass (SWRI 2002).

The preferred spawning substrate of striped bass, as observed in the Annapolis River, was reportedly mainly sand interspersed between basalt and granite boulders (Rulifson and Dadswell 1995). The average depth of spawning striped bass in the San Joaquin River was reported to be between 3.05 m and 22.9 m (10-75 ft) (Stevens 1966). Juveniles reportedly prefer clean, sandy substrates, but they have been found over gravel beaches, rock, mud, and mixed sand/silt substrates within estuaries along the west coast (Emmett et al. 1991). The average depth at which adults were observed within the Sacramento-San Joaquin River system was between 9.1m and 12.2m (30-40 ft) deep for holding adults (Stevens 1966).

Because striped bass mortality reportedly begins to occur at water temperatures that approach the highest observed water temperatures in One-Mile Pond, and because the dissolved oxygen requirements of the species reportedly fall within the range of dissolved oxygen concentrations observed in the pond, it is likely that suitable habitat exists within One-Mile Pond. However, striped bass were not observed in One-Mile Pond during electrofishing efforts.

5.2.2.5 Clupidae

American shad (*Alosa sapidissima*)

Moyle (2002) reported that the preferred water temperature for spawning American shad in the Sacramento River ranged from 17.0°C to 24.0°C (62.6-75.2°F). In the Feather River, water temperatures at which spawning occurred, and at which egg survival was high, were reportedly between 15.6°C and 21.1°C (60.1-70.0°F) (Painter et al. 1979). Moyle (2002) reported that the minimum dissolved oxygen concentration required for spawning American shad was five mg/L (Moyle 2002).. The preferred water temperatures for rearing juveniles in the Sacramento River were reported to be between 17.0°C to 25.0°C (62.6-77.0°C) (Moyle 2002). Little is known about adult water temperature preferences, although upstream migration may discontinue if water temperatures exceed 20.0°C (68.0°F) (Stier and Crance 1985).

Nest construction was reported to usually occur in sand and gravel in main channels of rivers (Moyle 2002). American shad spawning generally was reported to occur on broad flats in shallow waters (Painter et al. 1979). Preferred spawning depths are reported to be shallower than three meters (9.8 ft) (Moyle 2002). In a study conducted on the upper Delaware River, no relationship between juvenile abundance and habitat type was found, suggesting general use of most riverine habitat types. A positive relationship was found between juvenile abundance and cool water temperatures in riffles and also between and submerged aquatic vegetation in submerged aquatic vegetation habitats (Ross et al. 1997). Little evidence was found indicating a depth preference for adult American shad.

Because warm water temperatures are prevalent during the summer months in One-Mile Pond, it is unlikely that the pond provides suitable habitat for up-migrating American shad. However, water temperatures reported as suitable for rearing American shad do occur during some parts of the year in One-Mile Pond. Therefore, suitable habitat may exist within One-Mile Pond during certain parts of the year. However, American shad were not identified during electrofishing efforts in One-Mile Pond.

Threadfin shad (*Dorosoma petenense*)

Moyle (2002) reported that the preferred water temperatures for spawning threadfin shad are above 20.0°C (68.0°F) in June and July when spawning peaks (Moyle 2002).

Spawning, however, has been observed between 14.0°C and 18.0°C (57.2-64.4°F) (Moyle 2002). Growth and survival were reported to occur optimally in waters which exceed 22.0°C to 24.0°C (71.6-75.2°F) during the summer and do not become colder than 7.0°C to 9.0°C in winter (Moyle 2002). Threadfin shad reportedly cannot withstand water colder than 4.0°C for long periods of time (Moyle 2002).

Spawning is reported to occur most often at dawn around floating or partially submerged objects, such as logs, brush, and aquatic plants (Moyle 2002). Embryos reportedly hatch in three to six days and larvae immediately assume a planktonic existence (Moyle 2002). Burns (1966) reported in Moyle (2002) that threadfin shad reportedly prefer surface waters and are seldom found below depths of 18 meters.

Because the water temperature ranges in One-Mile Pond fall within the ranges reported to be suitable for threadfin shad, it is likely that the pond provides suitable habitat for the species. However, threadfin shad were not identified during electrofishing efforts in One-Mile Pond.

5.2.2.6 Ictaluridae

<u>Brown Bullhead (*Ameiurus nebulosus*)</u>

Becker (1983) has been reported by Moyle (2002) to suggest that the spawning season for brown bullhead in California typically begins in May and continues through mid-July. The onset of spawning, according to Becker (1983 *in* Moyle 2002), usually begins when water temperatures exceed 21.0°C (69.8°F). Becker (1983) also reported that adult brown bullhead individuals could live in water temperatures ranging from nearly zero °C to 37.0°C (32.0-98.6°F), but the preferred water temperatures seemed to range from 20.0°C to 33.0°C (68.0-91.4°F) (Moyle 2002). Becker (1983) and Loeb (1964) indicated that, when water temperatures are low, brown bullhead burrow into loose substrates and become torpid, and that this behavior may explain their ability to persist in cold streams (Moyle 2002). Feeding was reportedly observed at water temperatures as low as 4.0 °C (Moyle 2002). Low dissolved oxygen concentrations, less than 1.0 mg/L, can also be tolerated by brown bullhead (Moyle 2002). In situations where dissolved oxygen concentrations are low, the fish either become torpid when the low dissolved oxygen concentrations coincide with low water temperatures or brown bullhead gulp air when water temperatures are high (Moyle 2002).

Spawning nests are reported to typically be depressions in sand or gravel in close proximity to cover, such as beds of aquatic plants or fallen trees (Moyle 2002). After hatching (6 to 9 days, depending on water temperature), yolk-sac fry remain in the nest for another week or so, closely guarded by the parents (Moyle 2002). Little information exists regarding spawning depth preferences for brown bullhead.

Because brown bullhead can tolerate a wide range of water temperatures and low dissolved oxygen concentrations, it is likely that One-Mile Pond provides suitable habitat for the species. Also, brown bullhead were identified during electrofishing efforts in the pond.

6.0 ANALYSES

6.1 EXISTING CONDITIONS/ENVIRONMENTAL SETTING

Task 5B is a subtask of SP-F3.1, *Evaluation of Project Effects on Fish and their habitat within Lake Oroville, its upstream tributaries, the Thermalito Complex, and the Oroville Wildlife Area*. Task 5B fulfills a portion of the FERC application requirements by characterizing fish habitat in One-Mile Pond. Additionally, data collected for this task could serve as a foundation for evaluation and development of potential Resource Actions.

On November 21, 2002, April 4, 2003, and June 10, 2003 DWR conducted fish species composition sampling in One-Mile Pond. The results of DWR's electrofishing efforts are reported in the study plan report for SP-F3.1 Task 5A (DWR 2003).

In addition to the fish species reported by DWR as being present in One-Mile Pond during electrofishing efforts (DWR 2003), it is reportedly possible for additional fish species to be present in One-Mile Pond due to the proximity and seasonal connectivity of the pond to the lower Feather River (DWR 2001; DWR 2002).

According to DWR (2003), the most significant issue affecting the OWA fisheries in the last decade has been the invasion of water primrose (*Ludwigia peploides peploides*) in the OWA on the east side of the Feather River. Water primrose is a native aquatic plant that is currently found along the margins and backwaters of the Feather River both upstream and downstream of the OWA, and has increased in abundance since approximately the mid 1990s. A small flow of water has been passing through a portion of the OWA levee since the 1997 floods, which broke through the OWA levee on the east side of the river near the Pacific Heights Road entrance. Beavers have created a series of dams using the flow, which has spread the water across hundreds of acres of land that previously only flooded on a seasonal basis. Shallow water currently stands in the area of the beaver dams year-round, providing ideal conditions for the growth of water primrose, and its abundance has increased dramatically since the creation of the beaver dams. The excessive amount of water primrose in the formerly seasonally flooded areas has led to the spread of the species across the deeper, perennial, fish-bearing ponds. In some ponds within the OWA the entire surface area of the pond is covered with water primrose, sometimes up to a height of one meter above the surface of the water. High abundance of aquatic plants can have negative impacts to recreational fisheries through reduced angler access and effectiveness, as well as declines in largemouth bass foraging success (DWR 2003). Recent observations by DWR biologists, DFG personnel, as well as angler accounts, have estimated that 80% of the fish-bearing ponds in the OWA have been covered with water primrose, and this condition is increasing annually. A proposed Resource Action (EWG-29) may address this issue, and may include techniques such as water management, beaver and/or beaver dam management, aquatic plant removal with the use of mechanical equipment and/or chemical controls, and other suitable methods (DWR 2003).

This analysis, conducted for SP-F3.1 Task 5B, was completed on the fish species reported by DWR in the Study Plan Report for SP-F3.1 Task 5A as being present in One-Mile Pond and on those species reported by DWR as potentially being present (DWR 2001; DWR 2002; DWR 2003). The objective of the analysis was to determine whether suitable habitat exists within One-Mile Pond despite the recent spread of water primrose in the OWA.

6.2 PROJECT-RELATED EFFECTS

It is likely that the portions of One-Mile Pond sampled during water quality and habitat type sampling efforts provide suitable habitat for most non-native warm water species identified as having the potential to occur or that do occur in the pond based on the reported habitat preferences as well as the water quality tolerance ranges reported for the species. Additionally, based on the reported water quality tolerance ranges and on habitat types in which the fishes have been reportedly found, suitable habitat likely exists within One-Mile Pond for most native species identified as having the potential to exist in the lower Feather River below the Thermalito Afterbay Outlet. Exceptions do occur, however.

Water quality and habitat parameters reportedly tolerated by early lifestages of Pacific lamprey may exist in some portions of One-Mile Pond during some times of the year. However, the anadromous life history of the fish and the reported requirement of specific habitat types likely preclude adult Pacific lamprey residence in those portions of the pond where habitat and water quality sampling occurred. Tule perch may be able to tolerate conditions in portions of One-Mile Pond seasonally, but water temperatures greater than 25.0°C (77.0°C) were reported to generally exclude the species (Moyle 2002). Therefore, it is likely that tule perch are precluded from inhabiting those parts of the pond that exceed those water temperatures during the summer months. Green sturgeon habitat may exist in portions of the pond during the winter, but the species generally requires clear, cold waters and therefore is likely excluded from those portions of the pond with high water temperatures during the summer when water temperatures are most likely warm. White sturgeon juveniles reportedly prefer swift currents, which likely exclude them from One-Mile Pond. However, adult white sturgeon habitat may exist during the summer months when they are reportedly most active and prefer shallower water. Adult white sturgeon access to the pond, however, is likely limited during the summer months due to the controlled flow releases during the summer. Riffle sculpin are generally restricted to flowing water and waters with dissolved oxygen saturation, likely minimizing available habitat for the species in One-Mile Pond. Because Moyle (2002) reported that prickly sculpin have a relatively wide water temperature tolerance range, and can inhabit eutrophic water bodies as well as utilize many different substrate types, it is likely that suitable habitat for the species exists in portions of One-Mile Pond. Additionally, sculpin were observed during electrofishing efforts in One-Mile Pond but were not identified to the species level.

The introduced species identified as having the potential to exist in the lower Feather River below the Thermalito Afterbay Outlet are generally all reportedly well suited for existing habitat within One-Mile Pond, with the exception of three species, for which only seasonal habitat may exist in portions of One-Mile Pond. American shad are anadromous, and therefore habitat may only exist within portions of One-Mile Pond for juvenile rearing. Striped bass also are an anadromous species for which habitat may exist seasonally in portions of One-Mile Pond during juvenile rearing or when appropriate water temperatures coincide with adult spawning runs. Spotted bass adults were reported by Moyle (2002) to prefer deep (30 to 40 meters) reservoirs and areas in streams without “heavy aquatic vegetative growth". Therefore, it is unlikely that habitat exists within One-Mile Pond to support year-round resident spotted bass. However, other lifestages of spotted bass may exist in portions of One-Mile Pond.

7.0 REFERENCES

Aasen, K. D. and Jr. F. D. Henry. 1981. Spawning Behavior and Requirements of Alabama Spotted Bass, *Micropterus punctulatus henshalli,* in Lake Perris, Riverside City, California. California Fish and Game 67:118-125.

Bayer, J. M., T. C. Robinson, and J. G. Seelye. 2001. Upstream Migration of Pacific Lampreys in the John Day River: Behavior, Timing, and Habitat Use: Annual Report 2000. U.S. Department of Energy, Bonneville Power Administration, Environment, Fish, and Wildlife Department, Project Number 2000-052.

Beamesderfer, R. C. P. and M. A. H. Webb. 2002. Green Sturgeon Status Review Information.

Beamish, R. J. 1980. Adult Biology of the River Lamprey (*Lampetra ayresi*) and the Pacific Lamprey (*Lamptera tridentata*) From the Pacific Coast of Canada. Canadian Journal of Fisheries and Aquatic Science 37:1906-1923.

Brannon, E. and A. Sutter. 1992. Movements of White Sturgeon in Lake Roosevelt, Final Report 1988-1991. Project No. 89-44.

Brown, L. R. and P. B. Moyle. 1997. Invading Species in the Eel River, California: Successes, Failures, and Relationships With Resident Species. Environmental Biology of Fishes 49:271-291.

Carlson, A. R. and R. E. Siefert. 1974. Effects of Reduced Oxygen on the Embryos and Larvae of Lake Trout (*Salvelinus namaycush*) and Largemouth (*Micropterus salmoides*). Journal of the Fisheries Research Board of Canada 31:1393-1396.

Cech Jr., J. J., S. J. Mitchell, D. T. Castleberry, and M. McEnroe. 1990. Distribution of California Stream Fishes: Influence of Environmental Temperature and Hypoxia. Environmental Biology of Fishes 29:95-105.

Close, D. A. 2001. Pacific Lamprey Research and Restoration. DOE/BP-00005455-1. Portland: Bonneville Power Administration.

Counihan, T. D., A. I. Miller, M. G. Mesa, and M. J. Parsley. 1998. The Effects of Dissolved Gas Supersaturation on White Sturgeon Larvae. Transaction of the American Fisheries Society 127:316-322.

Coutant, C. C. 1977. Compilation of Temperature Preference Data. Journal of the Fisheries Research Board of Canada 34:739-745.

DFG. 2001. California's Living Marine Resources: A Status Report. California Department of Fish and Game Bulletin 465-466.

DWR. 2001. Initial Information Package. Relicensing of the Oroville Facilities. Federal Energy Regulatory Commission License Project No. 2100.

DWR. 2002. Study Plan Package- Presented to the Plenary Group by the Collaborative Work Groups: Land Use, Land Management and Aesthetics, Recreation and Socioeconomics, Cultural Resources, Engineering and Operations, Environmental.

DWR. 2003. SP-F3.1 Task 5A Report: One-Mile Pond Fish Species Composition. Oroville Facilities Relicensing FERC Project No. 2100.

Emmett, R. L., S. L. Stone, S. A. Hinton, and M. E. Monaco. 1991. Distribution and Abundance of Fishes and Invertebrates in West Coast Estuaries, Volume II: Species Life History Summaries. ELMR Report No. 8. Rockville, MD: NOAA/NOS Strategic Environmental Assessments Division.

FERC. 1994. 68 FERC 61, 358 Order on Revised Recreation Plan.

FERC. 2001. Conservation of Power and Water Resources. 18 CFR 4.51.

Fishbase. Acipenser Transmontanus, White Sturgeon.

Gadomski, D. M., C. A. Barfoot, J. M. Bayer, and T. P. Poe. 2001. Early Life History of Northern Pikeminnow in the Lower Columbia River Basin. Transactions of the American Fisheries Society 130:250-262.

Harvey, B. C., J. L. White, and R. J. Nakamoto. 2002. Habitat Relationships and Larval Drift of Native and Nonindigenous Fishes in Neighboring Tributaries of a Coastal California River. Transactions of the American Fisheries Society 131:159-170.

Kuenster, G. Percent Vegetation Cover in One Mile Pond- E-Mail Communication. October 9, 2003.

Lock, J. T. and J. T. Davis. 1997. Largemouth Bass: Biology and Life History. 200. Southern Regional Aquaculture Center.

Martin, R. Personal Communication. August 28, 2003.

Meng, L. and P. B. Moyle. 1995. Status of Splittail in the Sacramento-San Joaquin Estuary. Transaction of the American Fisheries Society 124:538-549.

Moyle, P. B. 2002. Inland Fishes of California. Berkeley: University of California Press.

Page, L. M. and B. M. Burr. 1991. A Field Guide to Freshwater Fishes of North America. New York: Houghton Mifflin Company, Painter, R. L., L. Wixom, and L. Meinz. 1979. American Shad Management Plan for the Sacramento River Drainage. Anadromous Fish Conservation Act Project AFS-17, Job 5. CDFG, Sacramento.

Parsley, M. J., L. G. Beckman, and G. T. McCabe. 1993. Spawning and Rearing Habitat Use by White Sturgeons in the Columbia River Downstream From McNary Dam. Transactions of the American Fisheries Society 122:217-227.

Ross, R. M., R. M. Bennett, and J. H. Johnson. November, 1997. Habitat Use and Feeding Ecology of Riverine Juvenile American Shad. North American Journal of Fisheries Management 17:964-974.

Rulifson, R. A. and M. J. Dadswell. 1995. Life History and Population Characteristics of Striped Bass in the Atlantic Canada. Transactions of the American Fisheries Society 124:477-507.

See, E. Methodology for Electrofishing in One Mile Pond- E-Mail Communication. September 30, 2003.

Siefert, R. E. 1968. Reproductive Behavior, Incubation and Mortality of Effs, and Postlarval Food Selection of White Crappie.

Stevens, D. E. 1966. Food Habits of Striped Bass, Roccus Saxatilis in the Sacramento-San Joaquin Delta. *in* Ecological studies of the Sacramento-San Joaquin Delta. Part II Fishes of the Delta. Fish Bulletin 136. California Department of Fish and Game. pp. 68-96.

Stier, D. J. and J. H. Crance. 1985. Habitat Suitability Index Models and Instream Flow Suitability Curves: American Shad. U.S. Fish Wildl. Serv. Biol. Rep. 82(10.88).

SWRI. 2002. Draft Implementation Plan for Lower Yuba River.

Taubert, B. D. 1977. Early Morphological Development of the Green Sunfish, Lepomis Cyanellus, and Its Separation From Other Larval Lepomis Species. Transactions of the American Fisheries Society 106:445-448.

U.S. Fish and Wildlife Service. 1995. Sacramento-San Joaquin Delta Native Fishes Recovery Plan. Portland, Oregon: U.S. Fish and Wildlife Service.

U.S. Fish and Wildlife Service. Sacramento Splittail (*Pogonichthys macrolepidotus*). Available at http://sacramento.fws.gov/es/animal_spp_acct/sac_splittail.htm

Wang, J. 1986. Fishes of the Sacramento-San Joaquin Estuary and Adjacent Waters, California: A Guide to the Early Life Histories. IEP Tech. Rep. No. 9.

Whyte, J. N. C., Beamish R.J., Ginther N.G., and Neville C.E.M. 1993. Nutritional Condition of the Pacific Lamprey (*Lampetra tridentata*) Deprived of Food for

Periods of Up to Two Years. Canadian Journal of Fisheries and Aquatic Science 50:591-599.